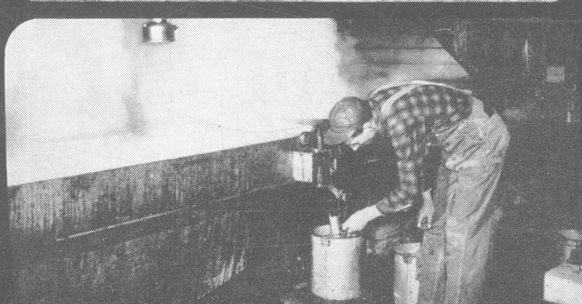
OHIO MAPLE SYRUP. . . *some factors influencing production*

H. R. Moore W. R. Anderson R. H. Baker



Research Bulletin 718 August 1951

OHIO AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

CONTENTS

ACKNOWLEDGMENTS

Much of the material in this study was assembled with the cooperation of more than 60 maple syrup producers who contributed so freely of their time and information over a period of four years.

The Central States Forest Experiment Station provided cooperative forest research funds during the first two years of the project, and assisted in the development of the work plan.

Several County Agricultural Agents in northeastern Ohio assisted in the organization of the field work. Howard Ward, photographer for the Division of Forestry, Department of Natural Resources, took most of the photographs, and Ture L. Johnson, Farm Forester, also of the Division of Forestry, assisted materially with the field work.

Peter T. Lannan, Jr., Karl Lindeman, James S. Ball, and James W. Meteer of the Department of Forestry, Ohio Agricultural Experiment Station, assisted during the course of the project in establishing test plots and collecting data.

Charles A. Reese, Assistant Professor, Department of Zoology and Entomology, out of his extensive experience in judging syrup exhibits, advised in respect to syrup standards and grades.

Ohio Maple Syrup . . .

SOME FACTORS INFLUENCING PRODUCTION

BY

H. R. MOORE, W. R. ANDERSON, R. H. BAKER

Summary and Conclusions

This is a study of some physical and economic factors related to the production of maple syrup in northeastern Ohio. Most of the findings will apply to other areas.

(1) Variations in weather, particularly during the sap-flow season, result in uncontrollable fluctuations in maple sap yields. Average annual yields, 1946-1949, ranged from one pint to more than one quart per bucket hung.

(2) Tests indicated that any soil type producing vigorous maples can be a satisfactory site for sap production; but sugar content in the sap was low on wet sites. Slope of land and direction of exposure did not have much effect on sap yields, if depth of soil was adequate. Steep slopes make sap gathering difficult and may have shallow soils which affect tree vigor.

(3) Fast growing trees are usually good sap producers. Large maples are the best producers. Volume of sap increases faster than tree diameter and sweetness of sap also increases with tree size. Apparently there are strains of sugar maples which produce much sweeter sap than do others; this merits more research.

(4) The volume of sap and its sweetness increased as density, depth and height of crown increased. In short, a large leaf-bearing area is associated with efficient sap production. Woodland management to reduce competition and encourage dominant or open grown type of trees with wide spacing is desirable.

(5) Some woods produced sap averaging 50 percent more sugar content than did others. Less time per gallon of syrup was needed to gather and boil sap and less fuel was used to evaporate the sweeter sap.

(6) Medium-sized sugar bushes, hanging 1,200 to 2,000 buckets, had lower average costs per gallon of syrup than smaller or larger bushes.

(7) Economy in fuel and labor to boil sap was greater with large-sized evaporators.

(8) Bucket covers increased gathering time slightly but reduced boiling time and fuel consumption (less snow and rain water).

(9) Average costs per gallon varied considerably among producers and by years. Years of higher yields show lower costs. Average cost in any year can be estimated closely if the yield is known.

(10) A timber inventory of sugar bushes indicated about one-half of the 10-inch and larger trees to be sugar maples. Although other species composed approximately one-half of the stand, saw timber production was distinctly secondary to syrup production. About one-third cord of fuel wood per acre in sugar bush was used in syrup production. Much but not all of this came from the area used for syrup production.

(11) On the half of the sugar bushes which were pastured, average costs per gallon of syrup were a little lower because of more open grown type maples; but reproduction of young maples was inadequate. Acre returns from syrup were lower on grazed bushes; due to fewer trees and buckets.

(12) Land cost in rented bushes was about the same as in owned bushes. Rental rates averaged about 5 cents per bucket hung in 1946 and 9 cents in 1949.

(13) The most usual method of marketing Ohio maple syrup is direct to consumer sales in gallon cans. This method is satisfactory when the supply of syrup is so limited that only a small part of the potential market is reached.

Study over a longer period might modify some of the results; but, from this four-year experience, some factors have been identified and evaluated for application to sugar-bush management and operation. The important conclusions are:

(a) Woodland management for maple syrup production should center on the development of limby, large-crowned maple trees. This is the direct opposite of the ideal type of tree wanted for timber production.

(b) At prevailing prices maple syrup production can be and usually is a more profitable use of land than timber production.

(c) Land, the cheapest factor in syrup production, can be used more liberally if in so doing one can economize on labor, fuel, and equipment.

(d) Efficiencies in operation favor the medium sized and larger bushes mainly because these justify the size of evaporator that economizes on labor, time, and fuel consumption.

(e) Demand and price during the period studied were adequate to encourage production. This has not always been true in the past. To maintain production, market prices for syrup must be high enough to cover the cost of production of most producers in most years. On the other hand, it is desirable from the standpoint of both producer and consumer to reduce costs by efficiencies in production as identified in this study. The extent to which a favorable combination of these can be attained by individual producers could largely influence the future prospects of the maple syrup industry.

INTRODUCTION

Maple syrup producers and other interested citizens in northeastern Ohio have expressed concern over the declining production of maple syrup and the cutting of sugar bushes. In several respects, this decline appeared to be unwarranted and undesirable. For instance, physical conditions in the area are very favorable to growth of sugar maples. Maple syrup production provides the opportunity for a relatively intensive use of land that may be better adapted to growing trees than to other uses. The income from maple products has been important to farmers and to others doing business with them. Maple syrup and its derived products are valued for their distinctive flavor, and both producer and consumer have an interest in maintaining the supply at a price satisfactory to both.

The problem faced in this study is to identify the combination of physical and economic circumstances that are favorable to profitable production of maple syrup. The question can be raised as to whether the basic problem is (1) physical, (2) a matter of production management, or (3) a matter of marketing. All three were considered important enough to be given some attention because the answer, if there is one, lies in some combination of all three.

Maple Sap Products Exclusively North American.—In an area surrounding the Great Lakes in the United States and Canada, east to the seaboard, and south through the Appalachian Highlands the white settlers found the Indians using maple sugar. The settlers adopted and improved on the Indians' methods of production, and maple syrup and sugar became common articles of diet. Difficulties of transportation and other costs made cane sugar a high-priced luxury in much of this area until after the Civil War. Since, the situation has gradually reversed itself and maple products have become luxury items to most people.

Production of maple sugar in the United States has declined steadily since 1860, while syrup production increased until about 1910. The peak of total production in the United States was between 1880 and 1890.

Production in Ohio has conformed in general to the national trend. The 10 leading states listed in order of 1916-50 average production are: Vermont, New York, Ohio, Michigan, Pennsylvania, Wisconsin, New Hampshire, Massachusetts, Maine and Maryland. Some maple products were reported from 71 Ohio counties in the census of 1910. However, the principal production is in northeastern Ohio centering in Geauga County which produces about one-third of the state's total in most years and is one of the leading counties in production in the United States.

Changes in Methods of Production.—The Indians' crude methods of production were to cut a gash in the bark of the maple tree, collect the sap in troughs of wood or bark, and boil it by dropping hot stones into the containers. Until about a century ago trees were generally tapped with a gouge, wooden spiles were used and the sap boiled in kettles over open fires to which the sap often was carried in pails suspended from shoulder yokes. By 1850-60 methods of production began to be modernized: augers were used in tapping, flat pans for evaporation, and sugar houses were constructed to protect the equipment. Changes since then have been partly to increase efficiency and partly to improve the quality of the product such as: larger gathering and storage tanks, filters, and evaporators with deeply corrugated bottoms economize on fuel and produce a lighter colored syrup by rapid evaporation. Metal spiles and sap buckets have replaced the wooden ones, although a few of the latter are still in use. Plastic sap bags are now being tested and may replace metal buckets if found desirable. Recently tapping machines are coming into use and the chain saw is to some extent replacing the hand operated cross cut saw, the drag saw and buz saw in the preparation of fuel wood.

These changes are interesting historically; but their main significance is that the production of maple syrup has passed from a simple household industry using crude equipment and much labor to a commercial enterprise involving more equipment and competing to a larger extent with other enterprises for the use of capital, labor, and land.

Changes are by no means complete. In a sense, this study reports the direction they are taking or may take if maple syrup production is maintained as a commercial enterprise.

Method of Study.—The approach to the problem was to study the physical and economic factors relating to production of maple syrup in individual sugar bushes.* More than 60 producers in Geauga, Lake, Ashtabula, and Portage counties cooperated.

* The term "sugar bush" as used in Ohio may mean any area supporting a number of maple trees and used as a source of sap for the manufacturing of maple products This general definition is used throughout this publication.

An inventory was made of each tract of woodland used as a sugar bush to determine the number and size of trees by species, and the volume of merchantable timber on each tract.

Production is primarily dependent on the sap flow from the individual tap hole in the individual tree. Thirty-five sample plots were selected in as many sugar bushes to intensively study site characteristics of soil, drainage, slope, and exposure and how such might relate to sap production. In each plot each tree was classified as to its physical characteristics and other factors which might influence the volume and sweetness of sap as revealed by periodic measurements through four years' production.

Viewed as a farm enterprise, the unit of production is the entire sugar bush operated by one producer. To study the costs in each bush, each producer supplied records of the time used to perform various

Figure 1.—A fifth-acre "test plot" located in a northeastern Ohio sugar bush. Sugar tests were made frequently throughout four syrup seasons and volume records were kept on the sap produced.

In other regions outside the State of Ohio the following nomenclature is often used: sugar bush — a natural, ungrazed forest area containing a workable stand of maple; sugar grove — an open stand (usually pasture-land) of either planted or natural maples, often without other species of trees being present; sugar orchard — a maple plantation used for production of maple sap.

operations, materials purchased, fuel used, sap collected, syrup produced and other information necessary to account for the resources and expenses relating to syrup production and marketing. The size of producing units ranged from less than 500 to more than 3,000 buckets hung. Records were kept for all four years, 1946-1949 inclusive, by 40 producers and for 3 years or less by more than 20 others.

Additional details of method are mentioned in connection with the analysis of various factors.

SOME FACTORS RELATING TO SAP PRODUCTION

Species of Maple

All native species of maple have relatively sweet sap. The sugar maple, also called the hard or rock maple, and the black maple are the best producers. However, red maple and silver maple are tapped to some extent. Small quantities of syrup have been made from the sap of the Oregon maple and box elder. The Norway maple, introduced as a shade tree, yields a milky sap unsuited to syrup production.

Sugar maple is an important species on forested uplands of northern Ohio; also, it is found associated with American beech and varying proportions of other species, on favorable sites over much of the state. To the south and west it is partially replaced by the black maple which is equally good as a syrup producer. In this study the few black maples encountered were included with the sugar maples in one general class of hard maples.

The few records available from other areas in the state indicate yields of syrup comparable to those of northeastern Ohio. However, it was in this area that the most maple trees were originally produced. Maple syrup is made in smaller scattered areas throughout the state.

Tapping Soft Maples

Tests indicated that soft maples (red and silver) usually produced sap low in sugar. This point is illustrated in Figure 2.

An occasional red maple located on relatively dry, good soil ran sap as sweet as the average hard maple, but the volume of sap was less.

Varieties and Strains of Sugar Maples

During the project field work it was observed that unusual leaf and bark characteristics of the trees located in a small area might not be repeated elsewhere. Also, some individual trees and test plots ran a sweeter sap than others when it was not possible to relate such variations to differences of soil, site or other natural factors. These observations suggest the possibility that different strains of sugar maples exist which so far have not been classified. Some strains may have the inherent

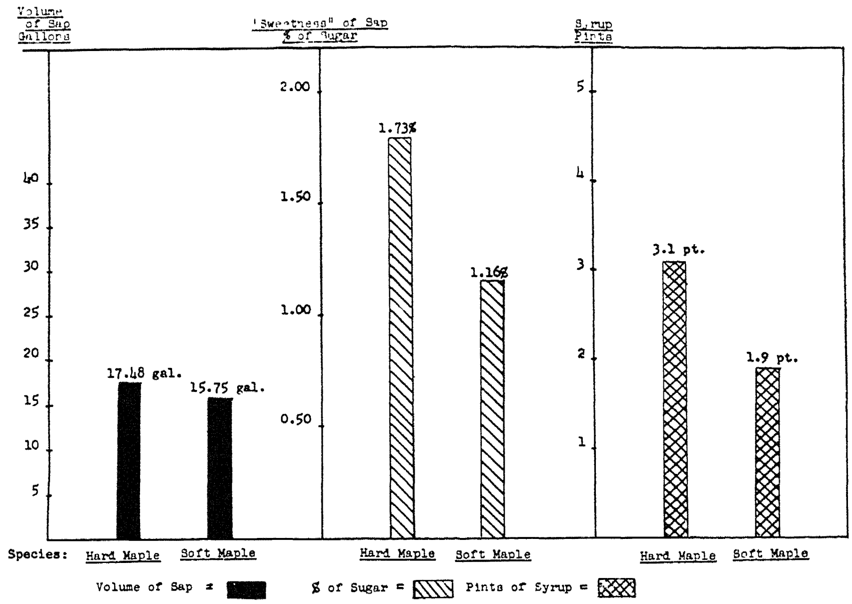


Figure 2.—This figure illustrates the reason for not tapping soft maples except under abnormal circumstances, such as an insufficient number of hard maples to justify tapping or certain soft maples growing on a well-drained site and known to produce sweet sap. Several "sweet" red maples were found during the study, but this was the exception rather than the rule and never were they located on a poorly drained site. This is a comparison of soft and hard maples growing on similar sites. It is on an average tree basis of similar size. Several hundred samples were studied over a four-year period.

characteristic of sweeter sap than others. The supposition is strong that tree heredity is of sufficient importance in syrup production to justify some intensive and more continued research than was possible in this study.

Climate and Weather

Maple trees grow best in a moderately cool, moist climate. All of Ohio meets this qualification fairly well. However, in respect to the critical period of late winter and early spring weather, northern Ohio usually has more prolonged periods when day and night temperatures fluctuate about the freezing point. This exacting weather condition must be obtained to induce a satisfactory flow of sap. Actually, sap runs can be obtained as early as December; but profitable runs seldom are obtained before St. Valentine's Day. In extremely favorable years satisfactory runs may occur over a period of 65 to 70 days. During that time runs worth collecting usually occur on only 20 to 35 days. In years of poor to average production the sap-flow season may be limited to 30 days or less with satisfactory flow on only 7 to 15 days. Once the weather continues warm, leaf buds open and conversion of the sap sugar to starch is started along with increased bacterial action in the spiles and buckets. For a few days in some years the sap may continue to run but produces an off-flavored or "buddy" syrup,—often dark colored or cloudy. Most producers prefer to make no "buddy" syrup which usually is unsuited to table use and sells at a discount.

Normal fluctuations in weather or climatic conditions from May through December appear to have very little effect on the yield of sap or its sweetness. The only noticeable effect appears following growing seasons distinguished by severe drought, bad insect attacks on the foliage, or a similar abnormal occurrence. However, the period that temperature and climatic conditions are vitally important, is during the critical period of sap flow. Then, weather not only conditions and brings about the sap run, but determines the speed of flow, duration of each run and the entire length and intensity of the sugaring season.

Warm rainy, or warm dry, windy weather tend to shorten the sugaring season. A period of several months of alternating cold and mild weather with plenty of warm, sunny days and clear, cold nights, with an abundance of ground moisture, is the best type of sugar season.

In some recent years weather forecasts by radio have specifically advised northeastern Ohio sugar camp operators when to expect sap runs. This has helped the individual producer plan his operations to take advantage of the weather.

Four years of observation illustrates the importance of weather in sugar bush management and syrup production as revealed by recording thermometer records, field notes and the records of 60 producers. The following data summarizes their experience. (Table 1.).

Table 1.—The Sap Flow Season and Syrup Yields: Based on the Experience of 60 Sugar Bush Operators Northeastern Ohio, 1946 to 1949 Inclusive.

Item	YEAR 1946	1947	1948	1949
Most usual date first run was gathered	Feb. 27	Mar. 12-13	Feb. 19	Feb. 18
Most usual date last run was gathered	Mar. 16	Apr. 11	Mar. 19	Mar. 26
Most usual number of days sap was gathered	8	11	11	15
Average production of syrup per 100 buckets hung .... gallons	14	25	19	28

Figure 3.—Testing maple sap for sugar content. The instrument used is a refractometer which gives percent of solids (97% to 98% sugar) directly. The tree shown is a large-crowned tree which produces large volumes of sweet sap. It is located in one of the permanent "test plots" in northeastern Ohio.

Tests[1] of individual trees indicated that the sugar (solids) content of sap ranged from a low of 0.3 percent to a high of 5.6 percent. Averaging all trees in each of the 35 plots indicated the sugar content of the sap to range from 1.3 percent on the poorest individual plot to 3.8 percent on the best (4-year records). The average sugar content in the sap from all plots in each of the four seasons studied was: 1946, 2.0 percent; 1947, 1.8 percent; 1948, 1.6 percent; 1949, 1.8 percent—a four-year average of 1.8 percent.

[1] These were refractometer readings which indicate the percent of solids in the sap. Readings were taken in the field directly from the fresh sap as it dripped from the spile when running freely. This was done to avoid errors arising from evaporation, if the reading is delayed. Figures used are based on repeated tests of each tree (approximately 10) spread over the sap season.

The above comparisons indicate how the sugar in maple sap varies with the tree, with the site and with the season.

Syrup weighing 11 pounds to the gallon contains 65 percent solids (of which 97 to 98 percent is sugar). Water in the sap has a lighter density than the solids.[2] It takes 86 gallons of sap containing one percent solids, or 43 gallons of sap containing two percent solids to produce a gallon of maple syrup. The records of 40 producers over a period of four years showed that an average of 44 gallons of sap produced a gallon of syrup. This indicated that the sap averaged slightly under two percent solids. Because the sweetness of sap varied from bush to bush it had a considerable influence on production costs which are discussed later.

Soil

This study was made in the area of glacial sandstone and shale soils. The most frequent soil series found on the undulating uplands is the Mahoning silty clay loam, and on the gently rolling uplands the Canfield silt loam. Of lesser frequency are the Ellsworth silty clay loam and Lordstown stony loam. The parent material (sandstone) of the latter generally lies 12 to 36 inches beneath the surface. In all the other soil series, 30 to 36 inches or more of glacial drift overlies the parent material of sandstone and shale.

No significant difference in sap production on the 35 sample plots could be related to any particular soil series except as such were related to drainage, depth of top soil and tilth. Most soils in the area have relatively poor internal drainage. The maple tree is tolerant of this condition, thriving on a cool moist soil, not excessively wet or dry. Deviation from this ideal condition lowered the yield of syrup, it being 14 percent less on the excessively drained plots and 6 percent less on the excessively wet plots. Sites with deep top soils[3] produced larger, more vigorous trees that flowed more sap. Sweetness of sap was unaffected by depth of top soil except when the depth was associated with relatively poor drainage.

All study plots were analyzed for soil nutrients, except nitrogen. The supply of available phosphorus was usually low, but apparently had no effect on the sweetness or volume of sap produced.[4] It is quite possible that nitrogen would have considerable effect on yield due to its influence

[2] One gallon of sap weighs 8.35 lbs. One gallon of one percent sap contains .0835 lbs. of solids. Therefore, one gallon of syrup weighing 11 lbs. and containing 65 percent solids contains 7.15 lbs. of solids. (7.15÷.0835=86 gallons of sap required.)

[3] Top soil as used throughout this discussion refers to the dark colored layer of soil at the top (A-1) which contains most of the organic material under undisturbed conditions.

[4] Tryon and Finn working at Black Rock Forest in New York found the hard maple to have approximately double the ability of other tree species to utilize a given amount of soil phosphorus.

on the amount and condition of the tree foliage. This factor undoubtedly accounts for a portion of the increased yield where adequate organic matter is present.

Soil tilth as related to sap flow was tested. Trees 14 inches in diameter, breast high, growing on the sample plots with loose mellow soil under abundant leaf litter averaged 24.1 gallons of sap per tree.

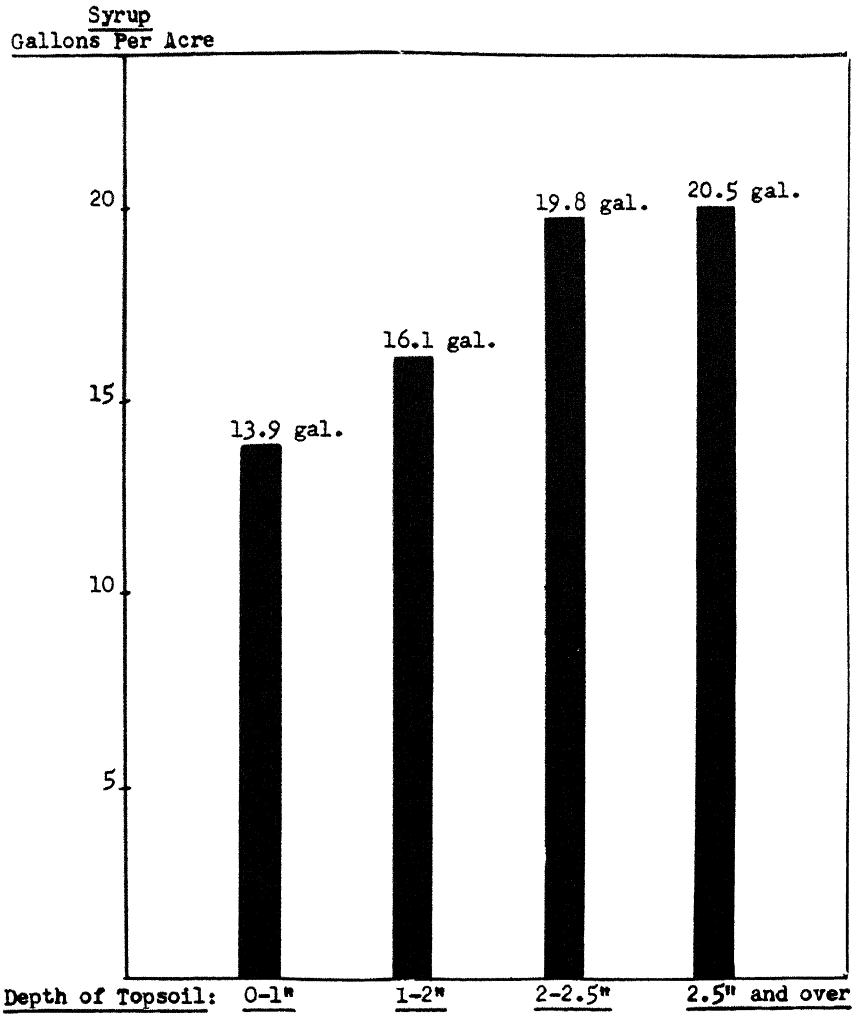


Figure 4.—Estimated yield of maple syrup per acre as indicated by 35 "test plots" over a four-year period. The tests indicated that syrup yield increased with increase in the depth of the dark layer of organic soil found in undisturbed woodlands. At excessive depths, however, the yield decreased, probably due to poor drainage conditions.

The same sized trees growing on soils compacted by grazing and with little or no leaf litter averaged 16.3 gallons. However, as will be indicated later, some other factors tend to offset the effect of soil compaction in grazed sugar bushes.

Topography and Exposure

The degree of slope alone could not be related to differences in yield of sap. However, steep slopes may have thinner top soils or dry soils which were associated with lower yields. Also, steep slopes may be a hinderance to gathering sap.

Yield on test plots was best on the slightly undulating to level upland with no pronounced slope, next best on northern slopes, about the same on east and west slopes, and poorest on south slopes. This follows the same pattern as forest tree growth indicating that sap production varies somewhat in proportion to rate of growth and vigor.

Presence of Other Species

The proportion of sugar maples in a natural stand is not so important as the number of large-crowned maples to be found on the area. Association with other species neither increased nor decreased the average yield per tree but decreased the yield per acre because less of the total space was available for maples.

Tapping Under a Large Limb or Over a Large Root

Records on 800 trees over a four-year period revealed no difference in sap yield from tap holes so located as compared with other tap holes.

Tree Mortality

On 35 one-fifth-acre test plots, totalling approximately 800 trees, 14 trees became mortalities, two were cut, and the ingrowth (trees reaching 8″ diameter) totalled 9 trees. Five trees were lost by windfall or died on pastured areas which could never be replaced by nature, while 11 trees were lost in unpastured plots.

The mortalities are listed as follows:

Nature of Mortality	Pastured No.	Unpastured No.
Windfall or top blown out	2	5
Died, reason unknown	3	1
Died, probably overtopped (young trees)	0	3
Cut (poor producers)	0	2
Total — 16 trees	5	11 Ingrowth 9 (only in unpastured plots)

The above illustrates the reasons for tree loss and that trees lost in ungrazed stands may be largely replaced through the ingrowth of young trees.

Tree Vigor

Crowded forest conditions as illustrated in Figure 5, do not permit the individual trees to develop into the most efficient syrup producers.

Figure 5.—Crown damage believed to be the result of poor vigor due to crowded forest conditions (long boles with small, spindly crowns) and extremely heavy tapping of small trees.

Direction of Hanging Buckets

From the standpoint of total seasonal production no difference in yield was indicated for buckets hung north, east, south, or west. Early in the season sap flow is best on the south side of the tree which warms up first. Flow on the south then declines and east and west holes produce better. Later, tap holes on the north produce best. This may be important in respect to the sequence of tapping. In the rush of opening the bush, buckets may be hung to the south to catch the first run or two before tapping is completed on the other exposures.

Competition With Other Trees

In any relatively dense, variable-age stand, some trees will be overtopped by others. The smaller trees will be suppressed in varying degrees. On the other hand, the large dominant or open grown trees will be exceptionally vigorous. Figure 6 illustrates these points as they occur naturally in the stand irrespective of size or number of buckets hung, and their effect on volume and sweetness of sap. The comparisons provided in Table 2 show the competitive position in relation to other trees and sap yield per tree and per bucket hung.

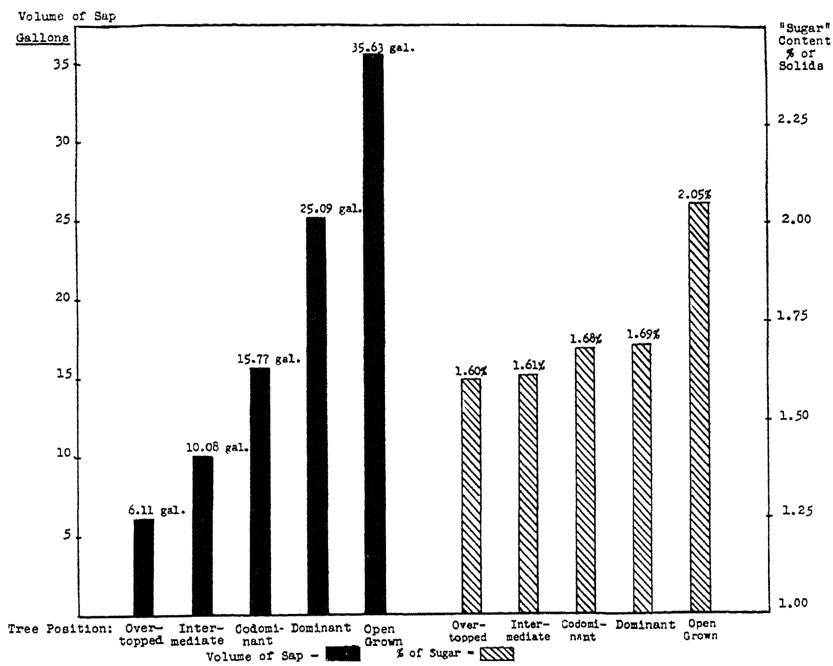


Figure 6.—Comparison of yields from trees of various relative positions in the forest stand.

The volume of sap increased considerably as the competition with other trees decreased, while the sweetness of sap increased only slightly with increase in degree of dominance of the forest grown trees. However, the open grown trees were far superior both in volume and sweetness of sap.

Length of Stem

Volume and sweetness of sap decreased with the limb-free length of forest-grown trees, which typically have relatively small-sized crowns. This emphasizes that management for syrup production should favor growth of large-crowned trees rather than the timber-type maple tree.

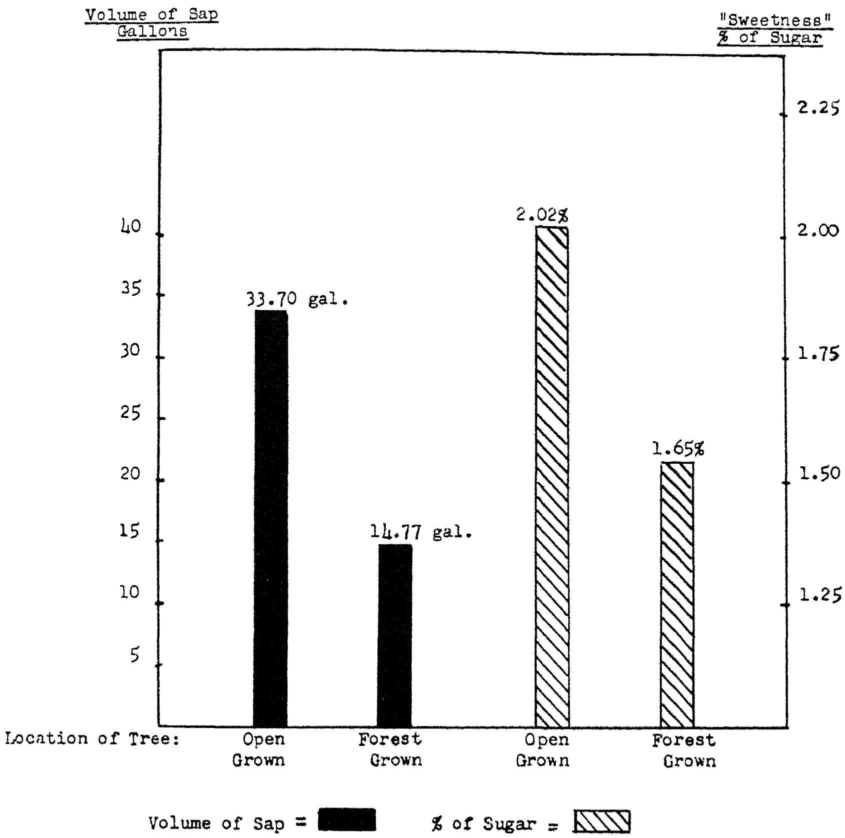


Figure 7.—A comparison of forest and open grown trees both in volume of sap and sugar (solids) content. When compared on an individual (average 16 inch in diameter) tree basis, the difference is very large. The best sugar bush takes advantage of the fact that trees must have room to grow, but yet contain the proper number of trees of a given age or size to fully utilize the space available with a minimum of competition. Basis — over 300 trees both open and forest grown over a four-year period.

Tree Size

Sap production tends to increase somewhat faster than does tree diameter or tree circumference. For instance, in Figure 8 the 30-inch tree is three times the diameter of a 10-inch tree but on the average produced 4.5 times as much sap.

The average yield of sap per bucket hung was: 8- and 10-inch trees, 6.55 gallons; 15- and 20-inch trees, 6.75 gallons; 25-inch trees, 9.01 gallons; 30-inch trees, 10.15 gallons; and 35-inch trees or larger, 12.45 gallons.

Table 2.—Yield of Sap Per Tree and Per Bucket Hung as Related to Competition from Other Trees. Averages of 4-Year Records, 35 Sample Plots, Northeastern Ohio, 1946 to 1949.

Class of Tree (As to degree of competition from other trees)	Average size of trees (diameter breast high) Inches	Sap Yield Per tree Gallons	Sap Yield Per bucket hung Gallons
Overtopped	11	6.11	6.11
Intermediate	14	10.08	7.20
Codominant	15	15.77	11.26
Dominant	16	25.09	17.92
Open Grown	16	35.53	25.45

Sugar content of the sap increased about one-fourth, on the average, between the medium size tree tapped and the largest tree (Figure 8). But factors other than tree size (diameter) were found to be associated with difference in volume and sweetness of sap. Three of these which relate to the total leaf surface of a tree are density of crown, depth of crown and width of crown. Figures 9 to 11 inclusive illustrate the average relationships of these factors to volume and sweetness of sap on the 35 sample plots.

Cull and Over-mature Trees

As long as crown or roots were unaffected, defects in the lower bole, such as hollowness, injuries, etc., did not affect the yield of syrup. Some large old trees, worthless as saw timber, were excellent syrup producers. This indicates how woodland management for syrup production may differ radically from woodland management for timber production. However, once the production of sap has seriously declined for any reason, the tree should be cut for timber, if reasonably sound, or, if not, should be used for fuel wood.

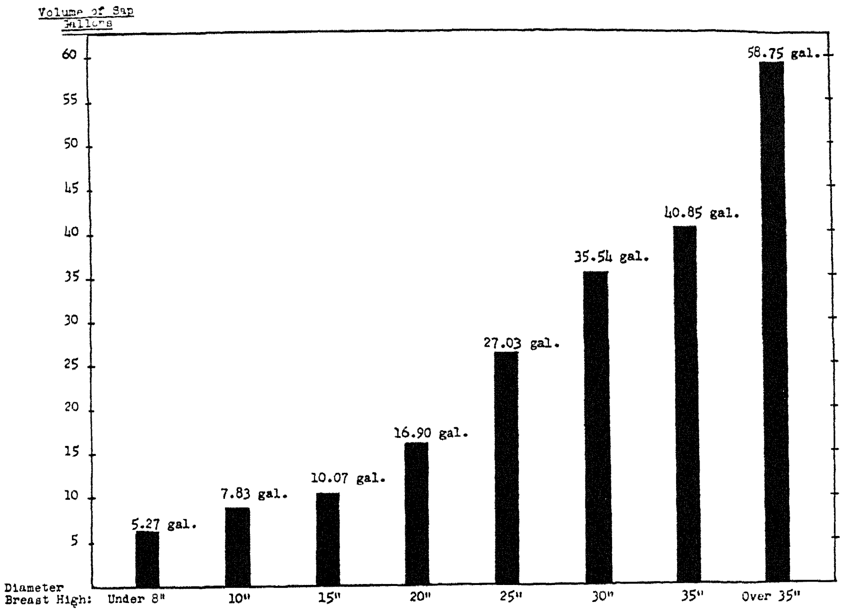


Figure 8 (a)—This shows the variation in volume of sap produced from average trees of different sizes (four-year averages on 35 "test plots").

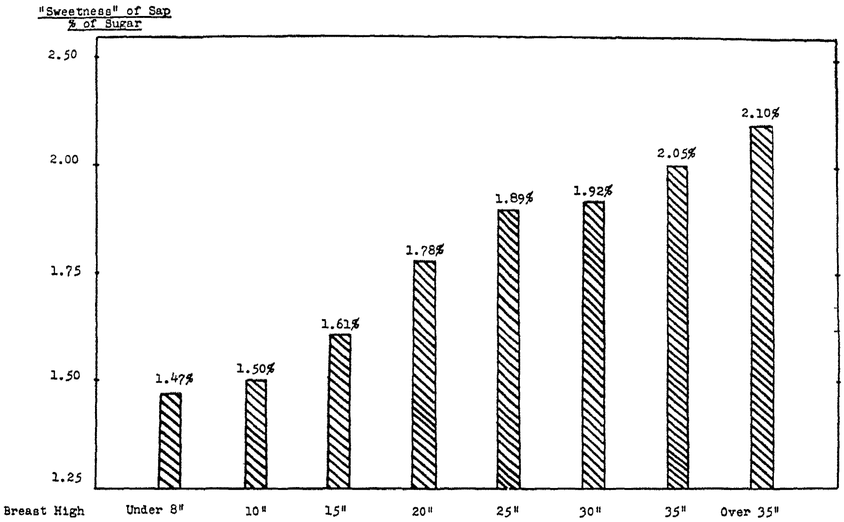


Figure 8 (b)—This shows the variation in sweetness of sap produced from average trees of different sizes (four-year averages on 35 "test plots").

Buckets Per Tree

Long experience has demonstrated that the following rule of thumb can be safely followed in respect to the number of sap buckets (with one tap hole per bucket) hung on different sized trees without seriously affecting the rate of growth or life-span of the trees:

1. Hang no buckets on trees less than 10 inches in diameter at breast height (4½ feet above the ground). Trees smaller than 10 inches may be permanently injured by tapping.
2. On a 10 inch to 15 inch tree hang one bucket.
3. On a 16 inch to 20 inch tree hang two buckets.
4. On a 21 inch to 25 inch tree hang three buckets.
5. On trees larger than 25 inches hang four buckets.

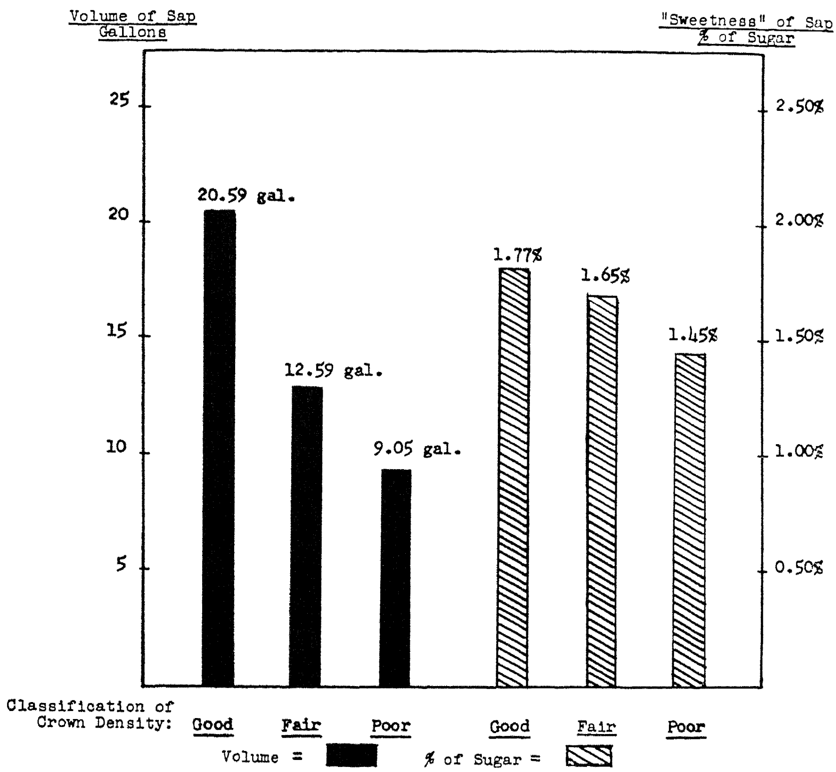


Figure 9.—Foliage density of individual tree influences the production of that tree to a large degree. Yields frequently are proportional to the amount of foliage or leaf area present on the tree. Averages were used from four-year records of 35 test plots, using trees of similar size (one size class).

The limitation to four buckets on large trees is because the rate of annual growth is slower on trees of this size and more years are needed to grow a new layer of sapwood over an old tap hole.

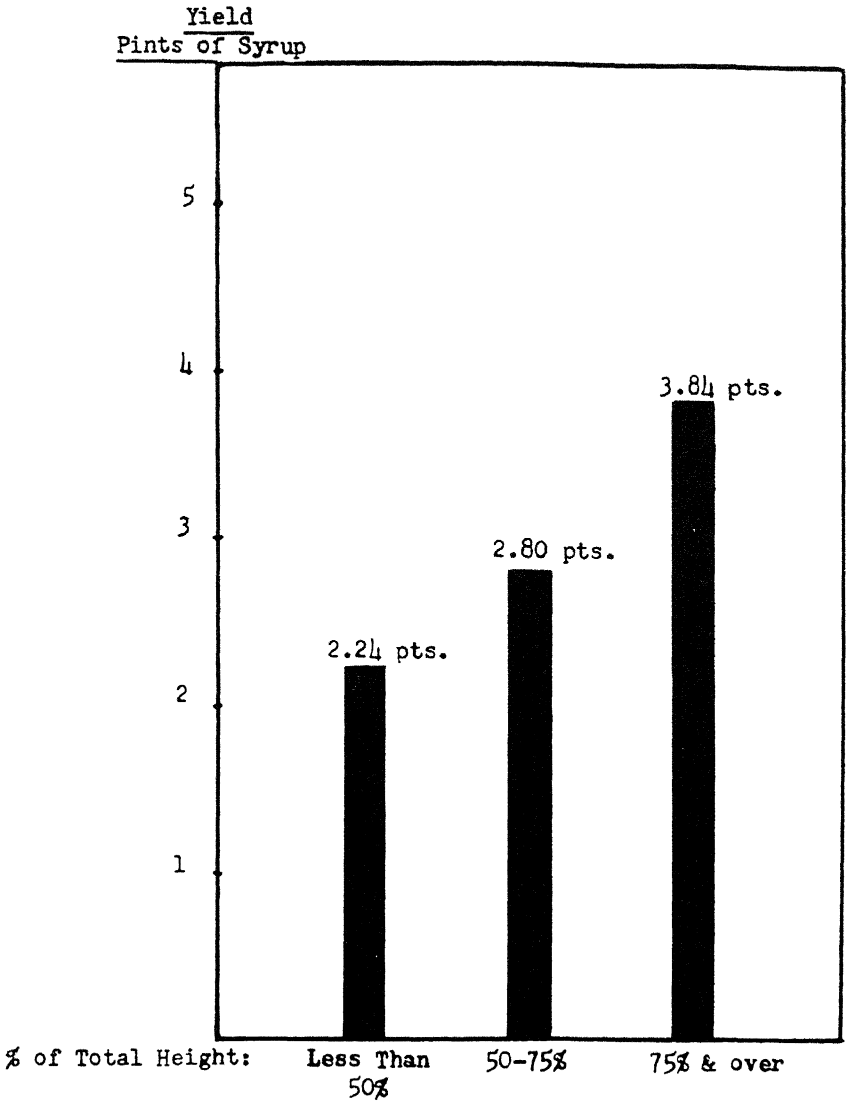


Figure 10.—The effect of height or depth of crown is shown here on 14 inch trees (D.B.H.). Compare this graph with that showing width of crown (Figure 11). Apparently it requires both depth and width to develop the ideal sugar tree. Basis — 300 trees over a four-year period.

As an average proposition, the sugar bushes studied were being tapped under the theoretical rates designated above, except the small trees, which were often overtapped.

Tests of individual maple trees and sample plots, as discussed above, help to identify several things which influence the volume and quality of sap. Some of these lend themselves to woodland management designed

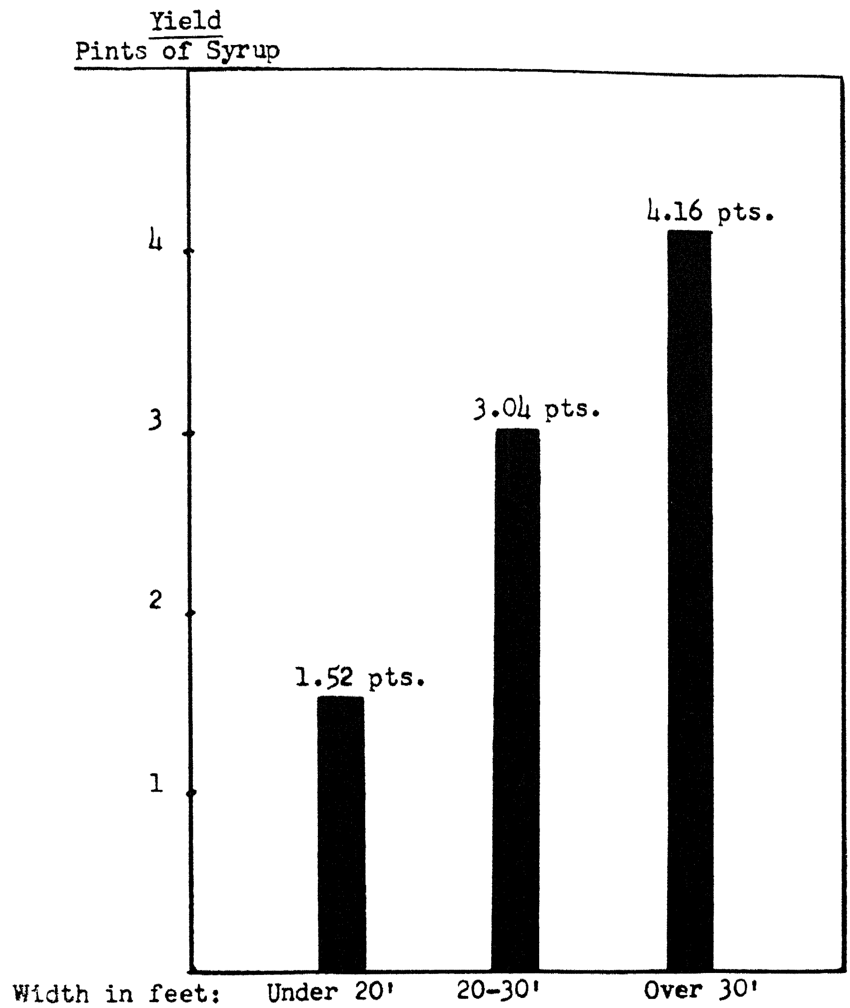


Figure 11.—Width of crown and yield of syrup compared. This is on the basis of similar diameter breast high with merely the difference in width of crown. This would indicate that a good sugar tree must have considerable width of crown. Apparently it's the total leaf area exposed to sunlight that pays off in the long run, moisture and other factors being equal. Basis — 300 trees in the 16 inch class (D.B.H.) over a four-year period.

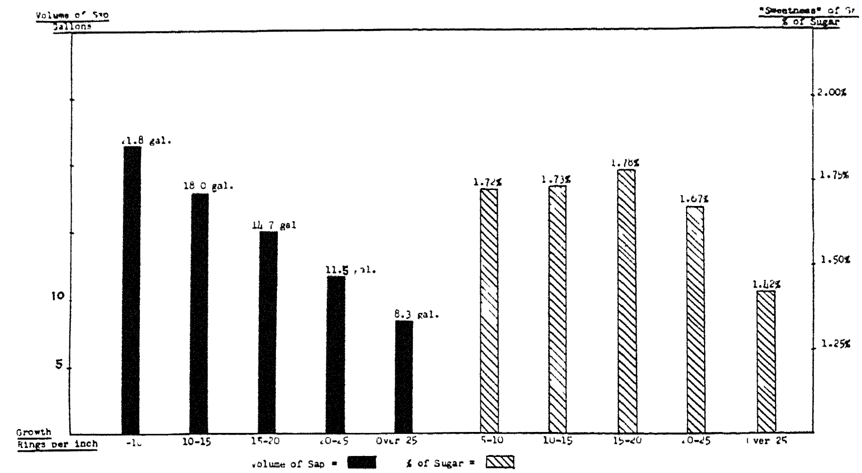


Figure 12.—Comparison of growth with yield of trees in the 12 and 16 inch diameter classes, hanging approximately 1.4 buckets per tree. Both average volume of sap and average sugar content is shown. Thus, it is readily noticed that there is a definite correlation between yield and growth rate. The faster the growth, the better vigor and the higher the yield of sap. Data were calculated on 35 sugar bushes over a four-year period.

to promote maple syrup production. The significance of these physical factors can be more fully evaluated when the total effort and expenditure going into maple syrup production is taken into account. To do this, the analysis of records kept by sugar bush operators will be introduced at this point.

COST OF PRODUCTION

Any important condition which lends itself to change through management needs to be tested in terms of its influence on the cost of production. The differences which have been pointed out in respect to test plots were found to apply to entire sugar bushes. To these differences can be added the variations in equipment and operating practices used by different sugar bush operators. In order to test all these things, so far as practicable, from 50 to 60 sugar bush operators kept cost account records in each of four years. Forty operators kept records for all four years and these are used for most of the cost analysis which follows. For a few comparisons, facts from all the cost records were used and all were valuable as a check on the other records.

The items included in production costs were: labor by the operator, his family, and hired labor used in the sugar bush and in syrup production; fuel for evaporating the sap; charges for use of the land and equipment; power costs (team or tractor); and containers and supplies.

Labor was charged at 60 cents per hour in 1946, 80 cents in 1947, 85 cents in 1948 and 90 cents in 1949. The charge for home produced fuel was $5.00 per cord in 1946 and $8.00 per cord in the next three years. Fuel purchased (mostly coal) was charged at market cost. Land charges included taxes on the area used in syrup production and an interest charge of 4 percent on the tax valuation. When trees were rented the land charge was the amount of rent paid. Equipment charges included depreciation based on the expected years of use, repairs, and interest at 5 percent on the depreciated value.

Hourly rates for team or tractor were respectively: 50 and 75 cents in 1946 and 1947; 65 and 80 cents in 1948; and 58 and 80 cents in 1949. Containers and supplies were charged at actual cost.

Calculated on the above described schedule of expenses, the 4-year average cost of production per gallon of syrup was $2.94.

For the average operator, labor represented 40 percent of the total cost of syrup production. He spent about 2/5 of a man-hour gathering a barrel of sap and 1/2 hour boiling time per gallon of syrup. Between 1/4 and 1/3 of the total time was spent getting the bush ready to operate and closing it. Tapping trees, hanging buckets, cleaning and assembling equipment and storing it again at the end of the season took about 8 hours per 100 buckets hung;—6 hours of which were expended opening the bush and 2 hours closing it down. For the 4 years the total labor cost per gallon of syrup produced averaged $1.24.

The second largest expense was equipment charges,—17 percent of the total, or 51 cents per gallon of syrup.

The third largest expense was fuel, 15 percent of the total. The average producer boiled down about 24 barrels of sap per cord of wood (or its equivalent) to produce 17 gallons of syrup,—a fuel expense of 44 cents per gallon of syrup.

Per gallon of syrup produced, the average expense for the use of land was 34 cents; team or tractor, 23 cents; and miscellaneous, 18 cents.

The above average costs serve as benchmarks in the analysis of these various factors which influence costs. In the following analysis of these various factors costs are expressed, so far as practicable, in physical units which remain more constant than money cost. On the other hand, money is the only common denominator which expresses all costs.

Sweetness of Sap and Cost of Production

Sweetness of sap affects gathering time, boiling time and amount of fuel necessary to produce a gallon of maple syrup. Its influence is clearly reflected in the analysis of 40 sugar bush records in Table 3.

Table 3.—Sweetness of Sap Related to Various Maple Syrup Production Costs, 4-Year Averages of 40 Producers, Northeastern Ohio.

Item	Sweetness of Sap (Gals. of syrup per 100 gallons of sap)						
	Under 2.00 gals.	2.00 to 2.14 gals.	2.15 to 2.29 gals.	2.30 to 2.44 gals.	2.45 to 2.59 gals.	2.60 gals. or more	Average
1. Number of farms	5	9	8	8	4	6	
2. Number of buckets hung per bush	880	1279	1198	979	1272	1107	1126
3. Gallons of syrup per 100 gallons of sap	1.87	2.09	2.22	2.35	2.55	2.76	2.28
4. Gathering time per barrel of sap, hrs.	.38	.38	.47	.38	.32	.36	.39
5. Gathering time per gallon of syrup, hrs.	.64	.60	.64	.55	.41	.40	.55
6. Boiling time per barrel of sap, hrs.	.37	.31	.37	.44	.32	.34	.36
7. Boiling time per gallon of syrup, hrs.	.59	.51	.53	.61	.40	.37	.51
8. Barrels of sap boiled per cord* of fuel wood	23.1	26.3	23.7	22.4	22.5	23.9	23.9
9. Gallons of syrup boiled per cord* of fuel wood	14.9	17.0	16.7	16.4	17.5	18.9	16.9
10. Average production cost per gallon of syrup	$ 3.17	$ 3.28	$ 3.04	$ 3.07	$ 2.28	$ 2.37	$ 2.94
11. Adjusted# gathering time per gallon of syrup, hrs.	.66	.62	.53	.56	.50	.43	.55
12. Adjusted## boiling time per gallon of syrup, hrs.	.57	.59	.52	.50	.45	.39	.51
13. Adjusted### gallons of syrup per cord of wood	15.4	15.5	16.9	17.5	18.6	18.9	16.9

* All fuel converted to wood equivalents.

Differences in labor and fuel efficiency per barrel of sap among classes in lines 4, 6, and 8 are due to factors other than sweetness of sap. If the effect of these other variations is removed, the effect of the sugar content of the sap is more clearly seen. "The following computations serve to equalize the factors of labor and fuel efficiency and to show the true effect of sweetness of sap on operating time and fuelwood consumption."

#Line 11—(Hours gathering per barrel of sap for 40 bushes ÷ values in Line 4) × values in Line 5.
Example: (.39 ÷ .38) × .64 = .66.

##Line 12—(Hours boiling per barrel of sap for 40 bushes ÷ values in Line 6) × values in Line 7.
Example: (.36 ÷ .37) × .59 = .57.

###Line 13—Values in Line 9 ÷ (Values in Line 8 ÷ barrels of sap boiled per cord of wood for 40 bushes).
Example: 14.9 ÷ (23.1 ÷ 23.9) = 15.4.

Sweetness of sap does not affect the amount of time necessary to gather a barrel of sap, and only has a slight effect on the time and fuel necessary to evaporate a barrel of sap to syrup (5). This fact was used in Table 3 to cancel out the random differences in labor time and in fuel consumption arising from operating efficiency. After being so standardized it was possible to measure approximately (6) the difference in time and fuel consumption arising exclusively from variations in sweetness of sap.

When sorted into six classes based on the sweetness of sap it was found that five producers having sap with the lowest sugar content recovered an average of 1.87 gallons of syrup per 100 gallons of sap processed; in other words, they gathered and boiled an average of 53.5 gallons of sap to obtain one gallon of syrup. At the other extreme, one group of six producers with sap having the highest sugar content obtained an average of 2.76 gallons of syrup per 100 gallons of sap. They gathered and boiled only 36.2 gallons of sap per gallon of syrup.

Further contrasting these extreme groups—to produce a gallon of syrup the operators with the thinnest sap handled 48 percent more volume, at the expenditure of 53 percent more gathering time, 46 percent more boiling time, 23 percent more fuel and 34 percent more total expense per gallon of syrup than did the men with the sweetest sap.

The above comparisons merely demonstrate the obvious: the sweeter the sap the less effort to produce a gallon of syrup. The fact that such a marked difference exists rather sharply illustrates the desirability (and the opportunity) of lowering the cost of production, so far as possible, by sugar bush management designed to produce the type of maple tree which flows sweet sap.

Size of Enterprise and Cost of Production

Size is no guaranty of efficient production. This study indicates however, that as a general rule, the smaller producers had the higher costs per gallon of syrup produced. The comparisons summarized in Table 4 suggest why.

Some additional economy in use of labor and equipment can be attained as more buckets are hung; at least up to 1,700 or 1,800. As shown in Table 4, that was the optimum point in cost per gallon of syrup. The most general reasons why average costs rose slightly in larger

[5] In contrast, the time and fuel expenditure **per gallon of syrup** varies inversely with the sweetness of sap.

[6] The impossibility of holding all factors absolutely constant under the actual working conditions of 40 different operators needs to be recognized.

Table 4.—Number of Buckets Hung Related to Maple Syrup Production Costs Measured on a Physical Basis and in Dollars, 4-Year Average of 40 Producers, Northeastern Ohio.

		Size Classes — Number of Buckets Hung						
		Under 675	675 To 974	975 To 1274	1275 To 1574	1575 To 1874	1875 And Over	Average
Number of farms		5	14	9	5	3	4	
Buckets hung per bush		578	817	1057	1418	1766	2205	1126
Gallons of syrup produced per bush		98	181	190	314	454	493	241
Gallons of sap per gallon of syrup		47	42	47	45	41	45	44
Gallons of sap per bucket hung		8	10	9	10	11	10	10
Gallons of syrup per bucket hung		.17	.24	.18	.21	.26	.21	.21
Gathering time per barrel of sap	Hrs.	.48	.43	.39	.30	.23	.37	.39
Boiling time per barrel of sap	"	.49	.42	.37	.23	.25	.20	.36
Boiling time per gallon of syrup	"	.70	.59	.53	32	.35	.29	.51
Total man hours per bucket hung	"	.33	.41	.27	.23	.25	26	.32
Total man hours per gallon of syrup	"	1.93	1.71	1.51	1.10	.95	1.24	1.51
Team (or tractor) time per bucket hung	"	.08	.09	.07	.06	.07	.07	.07
Team (or tractor) time per gallon of syrup	"	.48	.38	.39	.28	.26	.35	.35
Barrels of sap boiled per cord of wood**		21	23	24	27	25	26	24
Gallons of syrup boiled per cord of wood**		15	16	16	20	20	18	17
Present value (cost less depreciation) of equipment* per bush		$406	$612	$701	$612	$1073	$1841	$764
Present value of equipment per bucket hung		.70	.75	.65	.43	.61	.83	.68
Charges per bucket hung, dollars—Equipment		.13	.12	.10	.07	.08	.10	.10
Labor		.26	.30	.23	.20	.20	.21	.25
Team (or tractor)		.06	.05	.04	.04	.04	.04	.05
Fuel		.08	.11	.08	.09	.09	.08	.09
Land		.07	.09	.05	.07	.08	.05	.08
Total***		$.63	$.71	$.54	$.52	$.54	$.54	$.63
Charge per gallon of syrup produced, dollars—Equipment		.75	.53	.52	.33	.33	.46	.50
Labor		1.49	1.36	1.26	.93	.82	.95	1.20
Team (or tractor)		.34	.24	.25	.18	.15	.20	.23
Fuel		.52	.47	.44	.39	.36	.37	.45
Land		.40	.38	.32	.30	.33	.24	.36
Miscellaneous		.21	.20	.18	.19	.17	.20	.20
Total		$3.71	$3.18	$2.97	$2.32	$2.15	$2.42	$2.94

* Including sugar house.

** All fuel converted to wood equivalent.

*** Including miscellaneous expense not itemized.

bushes were the recent purchase of equipment at relatively high prices and that these bushes either were composed of two or more scattered areas in each case or the land was rough and broken. In other words, it is of some advantage to have the sugar bush area compact and easily worked over to save time in gathering and hauling sap. Given this condition, it is probable that costs would continue to go down in bushes hanging 2,000 or more buckets. Also, it may be pointed out that at prevailing syrup prices the operators of large bushes may have a little higher average cost per gallon and at the same time a higher total net profit than smaller operators.

Another cause for efficiency in the medium-sized and larger bushes is that they will justify the investment in a larger evaporator which economizes on both man-hours in boiling sap and in use of fuel.

It may be that the records tend to over-emphasize the economy of labor in the larger bushes, particularly in man-hours to gather sap. Proportionately more of the labor force in the larger bushes is represented by men in the prime of life. All the work in some small to medium sized bushes was done by men 65 to 75 years old; in others by a mixed force of family labor. Viewed as a commercial enterprise, however, it is concluded that economy in production of maple syrup favors the operator of a bush hanging 1,200 or more buckets because that size or larger will justify investment in adequate equipment to save labor time, and fuel.

Despite previous statements, it needs to be recognized that a few relatively small producers (hanging 600 to 800 buckets) were able to keep costs down to average or below. They did so by good management of good producing trees. Presumably, they would have had still lower costs by comparable management of larger bushes.

Number of Buckets Hung Per Acre

This merits discussion from two standpoints: (a) the influence on gathering time; and (b) the net return per acre.

The 4-year records of 40 producers indicated an average time of 23 minutes for a man to gather a barrel of sap. It is reasonable to assume that some less time would be consumed in gathering if a given number of buckets was densely hung over a small area instead of scattered over a large area. The records indicate that this difference may not be of primary importance in most situations. For instance, in those bushes hanging less than 27 buckets per acre, the gathering time per barrel of sap was 25 minutes; in contrast, in those bushes hanging 27 or more buckets per acre, the gathering time per barrel of sap averaged 23 minutes. But, of this latter group, three producers hanging 55 or more

Table 5.—Maple Syrup Production, Costs and Returns as Related to the Number of Buckets Hung Per Acre in Sugar Bush, 4-Year Records, 40 Producers, Northeastern, Ohio, 1946-1949 Inclusive.

	Number of buckets hung per acre							
	Less than 20	20 to 26	27 to 33	34 to 40	41 to 47	48 to 54	55 or more	All cases
Cases in sample	5	8	5	3	9	7	3	40
Average buckets hung per bush	756	941	1281	1205	1386	909	1630	1126
Average buckets hung per acre	17	23	31	35	45	51	68	37
Barrels of sap per acre	5.1	7.0	9.6	11.8	12.7	14.5	20.8	10.1
Barels of sap per bucket	.31	.31	.33	.32	.31	.27	.33	.31
Gallons of syrup per 100 gallons of sap	2.44	2.14	2.20	1.98	2.33	2.20	2.14	2.28
Gallons of syrup per acre	3.88	4.63	6.57	7.27	9.15	9.93	13.82	6.96
Gallons of syrup per bucket	.25	.22	.20	.19	.21	.19	.25	.21
Hours gathering per bucket	.11	.12	.10	.08	.10	.09	.12	.10
Hours gathering per barrel of sap	.35	.46	.35	.31	.39	.44	.44	.39
Hours gathering per gallon of syrup	.50	.65	.49	.44	.55	.62	.63	.55
Average cost per gallon	$ 3.26	$ 3.35	$ 2.52	$ 2.55	$ 2.78	$ 2.86	$ 2.74	$ 2.94
Average total expense per acre	$12.64	$15.51	$16.56	$18.54	$25.44	$28.40	$37.87	$20.46
Estimated total return per acre*	$19.40	$23.15	$32.85	$36.35	$45.75	$49.65	$69.10	$34.80
Estimated net return per acre**	$ 6.76	$ 7.64	$16.29	$17.81	$20.31	$21.25	$31.23	$14.34

* At selling price of $5.00 per gallon.

** After deducting all costs including an interest charge on land. This net return would represent first: payment for management and risk; any surplus then remaining could be considered as an additional reimbursement for the use of land. Some of the costs represent cash investments when prices were lower. If calculated on the basis of current replacement costs the net return would be lower (see page 30).

buckets per acre averaged 26 minutes per barrel of sap gathered, about the same as the group hanging the fewest buckets per acre.

Field observations indicated that rough, broken land may slow up the gathering rate; that age and physical capacity of the individual may affect the rate of work; that at least in some situations, the use of a tractor instead of horses slows up the rate of gathering. These and other reasons appear to be as important influences on the rate of gathering sap in individual cases as was the number of buckets hung per acre.

When converted to dollar costs per gallon of syrup produced, the highest cost producers were among those hanging the fewest number of buckets per acre. But the records did not indicate that these higher costs per gallon could be definitely related to physical difficulties of operation.

As measured by net returns per acre, the efficiency in the use of land was about in proportion to the number of buckets hung per acre. Actually, the records show the net returns (last line in Table 5) to increase slightly faster; but the difference could not be definitely related to the number of buckets hung per acre. As grouped in Table 5 the estimated net return per acre ranged from approximately $7.00 up to $31.00.

Under the method of cost analysis used in this study, the net return per acre (or per gallon) may be viewed as payment for management and risk of the operator and reimbursement for the use of land in addition to that already deducted as interest and the cost of taxes. How much should be allocated to each, except for taxes, is purely a matter of conjecture. On the other hand, the number of buckets hung per acre and the resulting net returns per acre can be considered a fair index of intensity in the use of land.

If current cost of replacement of equipment is used instead of the actual cost sometime in the past, (less depreciation) the average cost of production would be increased about 50 cents per gallon. This flat rate of increase per gallon would reduce the net returns per acre about one-fourth (assuming the market price of syrup to remain at $5.00 per gallon). In other words, at prevailing syrup prices a producer buying all new equipment and constructing a new sugar house could face higher costs and a smaller net return than that indicated in Table 5.

A question is, what intensity in the use of land is compatible with the lowest production cost per gallon of syrup? The main part of the answer lies in the relative size of various expenses which enter into the cost of production. As calculated in this study land costs represent, on the average, about 11 percent of the cost of producing a gallon of syrup as compared with 42 percent for labor and 15 percent for fuel. Land is the smallest expense of the three. As has been indicated in Table 3, sweetness of sap has a definite influence on the cost of production. And, the sweetest sap came from trees of the open grown type (Figure 6). Therefore, it follows that if low cost per gallon of syrup is the objective, the ideal sugar bush would be one which made a rather liberal use of land, allowing each tree relative freedom from the competition of other trees. Because the average sugar bush is only about 50 percent maples, opportunity usually exists for production of more and sweeter sap by the gradual removal of other species. Both a more intensive use of land and more space per maple tree are possible in the average situation.

Annual Variations in Yield and Cost of Production

Syrup yields vary from year to year mainly because of the kind of weather experienced during the sap-flow season. This variation in yield has considerable influence on the production costs of all producers as indicated by the figures in Table 6.

Table 6.—Comparison of Average Costs* Per Gallon of Maple Syrup, Records of Northeastern Ohio Producers, 1946-49.

	YEAR				Four-year Average
	1946	1947	1948	1949	
Number of records	58	49	52	47	
Gallons syrup produced per 100 buckets hung	13.98	25.14	18.67	27.78	21.39
Average expense per gallon syrup produced:					
Operator and family labor	.84	.80	.85	.81	.83
Hired labor	.42	.41	.45	.33	.40
Equipment (dep. & repair)	.53	.25	.36	.24	.35
Fuel	.38	.44	.45	.41	.42
Team or tractor	.26	.19	.28	.20	.23
Taxes and rent	.19	.14	.20	.11	.16
Interest on investment (land, sugar house and equipment)	.67	.28	.41	.26	.40
Containers, labels, shipping	.20	.17	.18	.22	.19
Average cost per gallon	$3.49	$2.68	$3.18	$2.58	$2.98

* These costs vary only slightly from the averages based on 40 producers who kept records for all four years.

The costs as calculated in Table 6 are based on the current costs of hired labor, fuel and supplies as reported by individual sugar bush operators. The fixed costs of interest and depreciation are based on the actual cost at the time of purchase of equipment or construction of the sugar house.

As calculated above, no allowance is made for the cost of management and risk incurred by the operator. The individual operator is reimbursed for these items according to his skill and luck from year to year. Obviously, some margin of profit above costs, as has been calculated, is necessary in the long run to encourage farmers to assume the risk and trouble involved in the operation of a sugar bush.

Maple Syrup Costs With Different Yields Per Bucket Hung

The purpose of Figure 13 is to provide a scale which will enable producers to estimate their average cost of production per gallon of syrup from year to year.

The types of charges that make up the cost of producing maple syrup might be classified as land charges, equipment charges, interest charges, fuel, containers, team*, and labor. The first three are fixed charges. They remain the same for a bush for a particular year whether a large or small amount of maple syrup is produced. But since the total charge for these items is constant for a bush the unit cost per gallon decreases in years when yields are high.

The last four items are variable charges. The annual expense for these items varies in about the same way as do yields.

Labor is the biggest item of cost. It makes up a little over one-third of the total cost of producing syrup. Some of the labor is a fixed item for a season including the time spent getting the bush into operation (tapping trees, hanging buckets, cleaning equipment, and setting up the stack) and closing the bush (gathering buckets, pulling spiles, and storing equipment). This fixed amount of labor amounts to about 8 hours per 100 buckets hung. The other increment of labor—that spent gathering sap and boiling and canning syrup—is one that varies with the amount of syrup produced. It requires about 1.1 hours per gallon of syrup produced.

Equipment costs make up 30 percent of the cost of producing syrup if the present replacement costs of equipment are considered. For a 1,200-1,500 bucket bush the equipment charge for a year will be $270 to $300.

Land charges make up 11 percent of the cost of producing syrup.

These last two items of cost are the same whether the yield is high or low. So the unit cost per gallon of syrup for these items decreases as yield increases.

Horse or tractor power accounts for about 7 percent of the cost of producing syrup.

* or tractor.

It takes one cord of wood for each 17 gallons of syrup produced on the average. This is .06 cords per gallon and when wood is $8.00 per cord that is equal to $.49 per gallon.

Container cost is about the same per gallon whether the yield is large or small.

When all of these charges are added together and the results are plotted as in Figure 13, it is possible, by inspection, to arrive at an average cost of production at any yield level. Four years of detailed field records have shown this technique to result in accurate estimations.

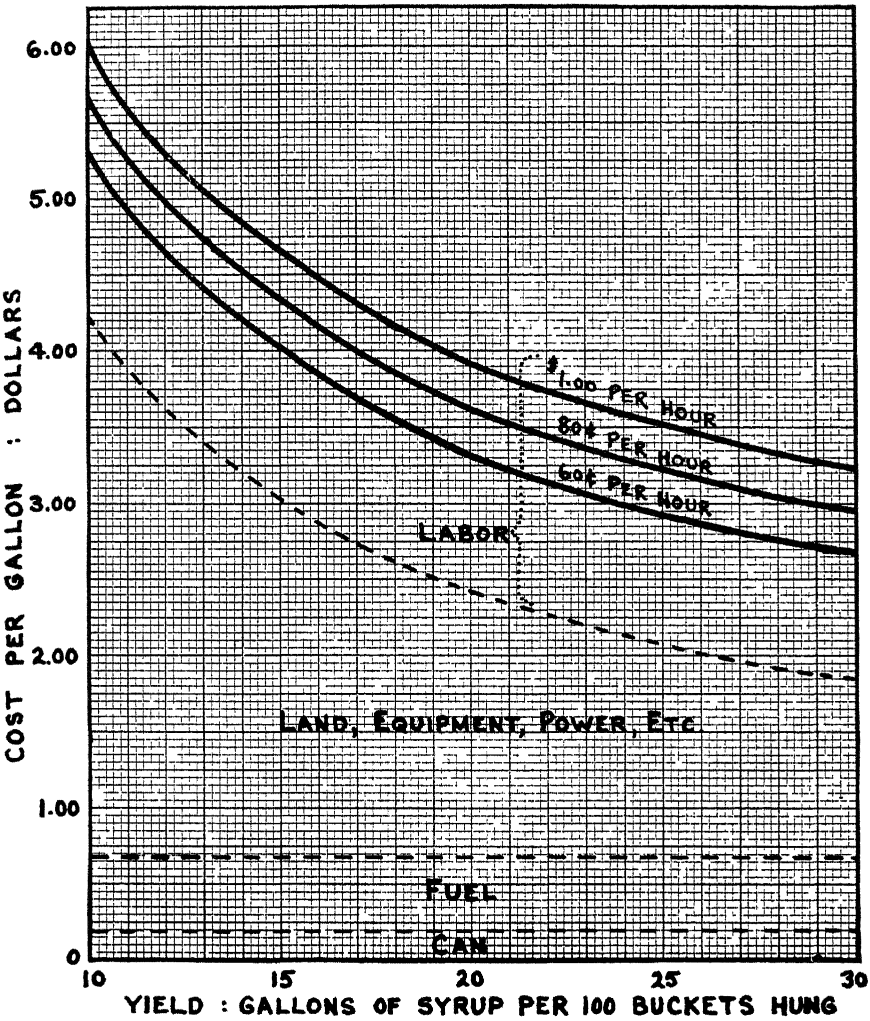


Figure 13.—Maple Syrup Costs with Different Yields.

The cost of producing maple syrup decreases from $5.71 per gallon when the yield was 10 gallons of syrup per 100 buckets to $2.95 per gallon when 30 gallons of syrup was produced per 100 buckets, when all labor was charged at 80 cents per hour. There are 3 lines that show costs at 3 different wage rates. Labor charge at 80 cents per hour varies from $1.52 per gallon at the lower yield to $1.09 per gallon at the higher yield. The charges for land, equipment at replacement costs, power, etc., vary from $3.50 per gallon at the lower yield to $1.17 at the higher yield. Fuel costs at $8.00 per cord of wood amount to 49 cents per gallon of syrup. Containers cost 20 cents per gallon.

Type and Size of Evaporator

The older style evaporators with flat bottoms provide less heating surface and evaporate the water in the sap less rapidly than the newer style evaporators of similar dimensions but having deeply corrugated bottoms. The figures assembled in Table 7 indicate the boiling time and fuel consumption relative to sap and syrup processed by type and size of evaporator.

Table 7.—Type and Size of Evaporator as Related to Man-Hours, Fuel Consumption, and Total Cost of Producing Maple Syrup, 4-Year Records of 40 Producers, Northeastern Ohio.

	Type and Size of Evaporator					
	Flat Pan*		Corrugated			
Item	Small (4'x10' to 4'x13')	Large (5'x16' to 6'x20')	Small (3'x12' to 4'x12')	Medium (4'x14' to 5'x14')	Large (5'x16' to 6'x22')	All Sizes
Number of cases	4	9	6	12	9	40
Av. No. of buckets hung	708	1076	748	1011	1769	1126
Gals. of syrup per 100 gal. sap	2.20	2.21	2.41	2.19	2.36	2.28
Boiling time per bbl. of sap, minutes	29	20	29	23	15	22
Sap boiled per cord of fuel wood, bbl.	20.5	26.7	21.7	22.0	26.2	23.9
Syrup produced per cord of fuel wood, gal.	14.6**	18.9**	15.3**	15.5**	18.4**	16.9
Av. production cost per gal. syrup—dollars	3.67	2.69	3.12	3.20	2.40	2.94

* No medium sized flat pan evaporators were in the sample.

** Adjusted to compensate for variations in the sweetness of sap. All fuel was converted to wood equivalent (1 T. coal — 2 cords of wood).

As analyzed in Table 7 the larger evaporators in both styles saved considerable boiling time as compared with the smaller evaporators. Likewise, efficiency in the use of fuel increased, probably because longer

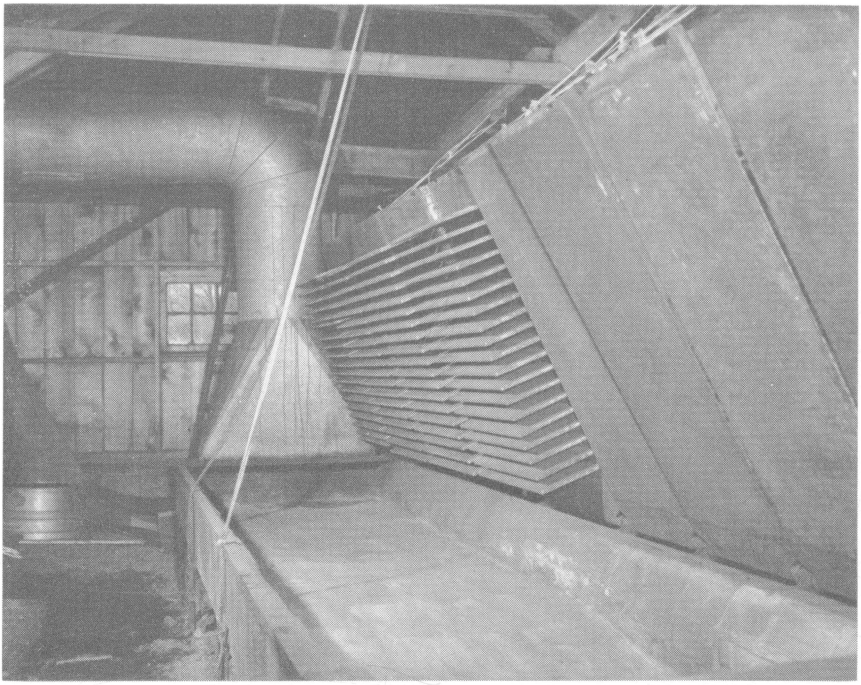


Figure 14.—Interior view of a well-kept sugar house following the clean-up following a sap run. Note that the evaporator flues, arch, and nearby equipment have been thoroughly cleaned. This large-sized evaporator economizes on labor, time, and fuel per gallon of syrup produced.

evaporators utilized the heat more effectively than shorter ones. No definite difference in efficiency in the use of fuel was indicated for the two types of evaporators. In this respect, enough variation was encountered in the quality of fuel wood to suggest that some of the difference indicated in Table 7 may have arisen from random variations in quality of fuel. It is fairly definite, however, that the large, corrugated type evaporator economizes on time of boiling more than the flat pan evaporator of similar dimensions.

Use of Covers on Sap Buckets

Some producers use no bucket covers, some on part and others on practically all sap buckets. The following analysis is confined to 14 operators using no covers and 15 who covered 75 percent or more of the sap buckets. How does the use of covers affect the cost of producing syrup? While a little extra labor and expense is incurred when covers are used the offsetting advantages are: keeping rain water out of the buckets and the recovery of a little more sap. Also, in the usual course of events, a little water or snow may not be dumped before the sap run and consequently sap from uncovered buckets may average a lower sugar content. The above considerations are in addition to the advantages gained by covers protecting the sap from leaves, twigs and other foreign material falling into the buckets.

Four years of records indicated the following:

(1) To produce a gallon of syrup required 47 gallons of sap when no covers were used, and 44 gallons when covers were used.

(2) A cord of fuel wood was consumed to produce 16.8 gallons of syrup when no covers were used and 17.8 gallons when covers were used.

(3) Gathering time per barrel of sap was .29 hours when no covers were used, and .33 hours when covers were used.

(4) Other factors also influence the costs and when all were taken into account no difference on the average production cost per gallon was indicated whether covers were used or not.

The decision as to the use of covers therefore appears to rest on how much they help produce a better quality of syrup.

Woodland Inventory

An inventory was made of the woods where records of maple syrup production were kept for this study. It covered 87 wooded tracts owned by 68 different people. The purpose was to determine the volume and estimated value of the merchantable timber and the characteristics of each tract which might influence its use for the production of maple syrup.

On the 1942 acres covered by the inventory the estimated total amount of saw timber was 9,282,519 board feet with an estimated stumpage value of $250,085. This represents a per acre average of 4,779 board feet valued at $128.76. In density of stands, the tracts varied from 340 board feet per acre valued at $10.20 on an open park (or pasture field) area up to 9,780 board feet valued at $272.61 in a heavily forested area.

The average number of trees per acre, 10 inches or more in diameter, breast high, was: hard maple, 19.4; soft maple, 2.4; and other species 22.4; a total of 44.2 trees per acre. The average carrying capacity was 40.2 buckets per acre, ranging from 8.4 buckets on one tract up to 101 buckets on another. In calculating this bucket carrying capacity soft maples were included only in those cases where the operator tapped soft maples.

The above circumstances emphasize that woods used for maple syrup production are far from uniform. Nearly all the trees in some woods are hard maple but the more typical woods contain a surprisingly large proportion of other species. It may be pointed out that over a period of time woodland management and harvesting practices can increase the proportion of hard maple to practically 100 percent of the total stand.

No definite relationship existed between the amount of merchantable timber and the bucket carrying capacity or the sweetness of sap.

Saw Timber Harvested

Most woodland used for maple syrup production is also potentially capable of producing some saw timber. The question is, how much is actually recovered? The results of four years' study are as follows: In 21 out of 40 cases (where records were kept for all four years) some saw timber was cut either for home use or for sale. At this rate it can be estimated that on any one particular tract some trees would be utilized for saw timber about once in eight years. The 21 cases represented a total cut of 62,115 board feet for sale and 60,638 board feet for home use. For that sold, the sum of $2,130.70 was received (stumpage value) at an

Figure 15.—A new sugar house built entirely from native hardwood species other than sugar maple which were removed while improving the farm sugar bush. Note that construction has begun on a large fuel-wood shelter.

average price of $35 per thousand. At an estimated value of $30 per thousand, that used at home would be worth $1,819. The saw timber harvested for sale or home use would represent an annual average return of 84 cents per acre (for 26 board feet) for the 40 cases. It should be recognized that the amount of saw timber harvested may have a very indefinite relationship with that potentially available for harvest.

This relatively low volume of saw timber may be partially explained by the fact that a relatively large volume of fuel wood is used in the production of maple syrup.

Fuel Wood

The tracts of woodland used for maple syrup production also furnish much of the fuel wood to boil the sap. In the usual course of events, most of the fuel wood is harvested as a salvage operation although some potential saw timber is cut for fuel. Defective trees, dead trees, and windfalls occur in any woods. To some extent, utilization of this wood to boil sap is an outlet for material that might otherwise be wasted.

Covering records for four years, the average of 40 syrup producers hung 1,126 buckets and used 11 standard cords of wood and some coal. If this coal is converted to wood equivalent, the total fuel consumed would equal 14 cords of wood or about one cord for each 80 buckets. But excluding the coal the average producer actually used about one cord of wood for each 100 buckets or .36 of cord for each acre in sugar bush.

Pasturing the Sugar Bush

The study of sample plots in grazed bushes as compared with ungrazed bushes indicated that,—provided an adequate stand of maple trees existed on the grazed plot,—the yield of syrup was as good or better than on ungrazed land. It can be pointed out that plots in grazed sugar bushes usually had more trees of the large crowned, open grown type which tests indicated to be the best producers. Also, grazed sugar bushes contained a greater proportion of large diameter old trees which were good producers. Naturally, if grazing had been heavy and continuous few or no young trees were coming on as replacements; but this did not always limit current production. The adverse effect of soil compaction in the grazed sugar bushes apparently was more than offset by the factors of tree size and crown size. The well stocked one-fifth acre sample plots in the grazed bushes produced at the rate of 22.6 gallons of syrup per acre and in the ungrazed plots at the rate of 20.2 gallons per acre. Both illustrate the superior capacity of a well stocked area

Table 8.—Costs and Returns from Maple Syrup Production in Ungrazed and Grazed Sugar Bushes, Averages of Four Years Production, 1946-1949, Northeastern Ohio.

Item		Class of Bush		
		Ungrazed	Recovering from grazing	Grazed
Number of cases classified		10	8	18
Average size of bush	acres	27	24	39
Av. buckets hung per bush	number	1103	1014	1023
Av. tappable trees per acre*	number	28	28	17
Av. buckets hung per acre	number	41	42	26
Total barrels of sap	number	336	343	305
Barrels of sap per acre	number	12.4	14.3	7.8
Barrels of sap per bucket	number	.30	.34	.30
Total gals. of syrup produced	number	218	219	221
Gallons of sap per gal. of syrup		47.6	48.6	42.8
Gals. of syrup per acre	number	8.11	9.13	5.67
Gals. of syrup per bucket	number	.20	.22	.22
Hours gathering per 100 buckets	number	10	10	11
Average cost per gallon	dollars	3.16	2.96	2.93
Av. total expense per acre	dollars	25.63	27.02	16.61
Est. total return per acre**	dollars	40.55	45.65	28.35
Net profit per acre***	dollars	14.92	18.63	11.74

* Hard maples 10" and over, D.B.H.
** At selling price of $5.00 per gallon.
*** After deducting all costs including interest charge on land.

as compared with syrup production per acre in the average sugar bush (Table 8).

A study of the production from the entire sugar bush, grazed and ungrazed, revealed several points recorded in Table 8 which can be summarized. The average cost of production of a gallon of syrup was not significantly different in grazed and ungrazed bushes. The average number of buckets hung per acre was significantly greater in the ungrazed bushes and, because of this, a little less time was necessary to collect the sap per 100 buckets. The increased net return per acre in the ungrazed bushes indicated that at current syrup prices the production of syrup is a more profitable use of wood land than grazing. A relatively unintensive use of land was indicated in the grazed bushes (average, 26 buckets per acre).

On the scale of production costs used in this study, the average syrup producer would about break even if he sold syrup at $3.00 per gallon. At some such point in price, current income from the land would favor either straight timber production or use as pasture rather than syrup production. The crux of the matter is that the average grazed bush is on its way to conversion to pasture and cannot be permanently utilized for both sap production and pasture unless special effort is made to plant and protect the young maples needed for replacements. Some producers are doing this to a limited extent.

Charge for the Use of Land Owned or Rented

About 85 percent of the maple syrup production covered by this study was on land owned by the operator. The land charge involved in producing syrup on both owned and rented land was calculated as follows:

When on owner-operated land, the maple syrup enterprise was charged with all the real estate tax on the land in sugar bush, and with 4 percent annual interest on a land-tax-valuation averaging $33.91 per acre but ranging from $25 to $50 in individual cases. This valuation does not include any allowance for the value of the timber on the land. This low valuation and interest charge were used because most land used in maple syrup production is also used for other purposes,—pro-

Figure 16.—A contrast between the grazed and ungrazed sugar bush. Note the vast difference in ground cover.

duction of saw timber, fuel wood, and in about one-half the cases, for pasture.

To explain further:

(1) Under fair to good growing conditions woodland adds 3 to 5 percent to the volume of wood each year which should about offset an annual interest charge on the value of the existing stand of merchantable timber.

(2) If pastured, the annual tree growth might be less but the land should be credited with the value of the forage, although such forage is usually recognized as being very low in nutrient value.

(3) Much of the fuel wood used to boil the sap came from the sugar bush area and the maple syrup enterprise was charged with the value of this wood.

(4) In case timber was sold from the sugar bush area the maple syrup enterprise was not credited with this income.

By the foregoing method the land charges of interest and taxes averaged 5.15 cents per bucket hung or slightly more than the average rental charge per bucket in 1946 when the study was started.

Renting Maple Trees

Several different types of rental arrangements involving maple trees were encountered. (1) A farm or tract of land might be cash or share rented. The use of a sugar bush and even sugar making equipment might be included with no separate rental price stipulated for such, or (2), trees might be rented for a lump sum in cash; or (3), for a certain number of gallons of syrup; or (4), for so much per bucket hung. It is probable, regardless of the terms of the lease, that most people arrived at a rental by some estimate of bucket carrying capacity of the area rented. At least, to put all maple tree rentals on a comparable basis the figures in Table 9 express rentals as the amount paid per bucket hung. Because maple syrup prices increased from 1946 to 1949, rentals are shown for each year. Average rental rates have gone up too.

Table 9.—Rental Rates Paid for the Use of Maple Trees for Syrup Production, Northeastern Ohio, 1946-49.

Year	Number of cases in sample	Rental rates (in cents per bucket hung) Range Lowest	Highest	Average
1946	9	3	13	5
1947	8	3	16	8
1948	12	3	29	9
1949	9	3	16	9

When put on a land area basis rentals ranged from about one dollar up to 10 dollars per acre gross return to the land owner, and averaged about $2.00 per acre in 1946 and $3.50 in 1949.

It will be of interest to maple syrup producers that the above average rentals are approximately equal to the price of two gallons of syrup for each 100 buckets hung regardless of the year. Paying rentals in a fixed quantity of syrup has the advantage of automatically adjusting the rent to changes in syrup prices.

MARKETING

State Standards for Maple Syrup and Maple Sugar

The intent of the Ohio law is to prevent adulteration by specifying certain standards and providing for labeling.

The General Code (Sec. 12763) identifies maple syrup (or maple sugar) as the unadulterated product by evaporation of the sap of the maple tree. Any other substance purporting to be maple syrup or maple sugar is considered to be an adulteration. A gallon (231 cubic inches) of maple syrup weighing less than 11 pounds is legally an adulteration. Penalties are provided for adulteration or for the use of the word "maple" except on the pure product.

The Ohio law (G.C.Sec. 17766) provides that a package of maple syrup or maple sugar sold or in possession with intent to sell must bear the name and address of the packer and also the state, territory or country in which it was produced.

Compliance with the above specifications is supervised by the State Department of Agriculture. Because pure maple syrup is a luxury product it offers some opportunity for fraud by adulteration and sale under fake labels or under counterfeit labels of reputable dealers or producers. The purchaser needs to be particularly on guard against offers of an unknown product by unidentified strangers at cut-rate prices.

Grades of Syrup

Syrup with a clear, light amber color, free of all cloudiness and with the characteristic mild maple flavor is considered to be the highest quality product. On the other hand this is to some extent a matter of individual preference, some people prefer a medium amber or even dark amber syrup having a stronger flavor.

Ohio producers have been encouraged by the State Department of Agriculture and the Agricultural Extension Service to conform to the following U. S. standards for recognition of quality. These standards apply to: (1) table grades and (2) reprocessing grades. The color is judged on a scale of 9 from light amber to dark amber, and the table grades are also classed on a scale of 9 in respect to cloudiness. Other grade requirements are freedom from foreign material and specific gravity (11 pounds to the gallon. At this weight syrup is 65 percent solids). Following are the color and cloudiness specifications applying to these maple syrup grades:

Table Grades:

U. S. AA Fancy,	color not darker than 5, cloudiness not more than 5
U. S. A,	color not darker than 7, cloudiness not more than 7
U. S. B,	color not darker than 9, cloudiness not more than 9

Reprocessing Grades:

U. S. AA,	color not darker than 5, (not graded as to cloudiness)
U. S. A,	color not darker than 7, (not graded as to cloudiness)
U. S. B,	color not darker than 9, (not graded as to cloudiness)
U. S. C,	color darker than 9, (not graded as to cloudiness)

Syrup not meeting the above quality specifications because of scorching, buddiness or for other reasons is adapted to some commerical uses such as flavoring for tobacco.

Annual exhibits of syrup by producers at the state and county fairs and at the Maple Festival at Chardon, Ohio are judged according to the above described grades. This has encouraged producers to recognize and conform to standards based on the qualities which influence market price.

In the period of this study, nearly all the syrup produced was sold or ordered shortly after the close of the syrup-making season. Many producers supply the same customers from year to year. Only in years of large production is there any substantial amount of syrup in the hands of the producers after the first of May. In years of short production, as 1946, not all orders were filled.

The large urban population adjacent to the principal area of Ohio's syrup production supplies a large potential market for direct to the consumer sales. In recent years this market has been adequate for practically all the table quality syrup produced. Some Ohio maple syrup is assembled by packers who market under their own label.

Type and Size of Container

In Table 10 is indicated the aggregate amount of maple syrup sold by approximately 60 northeastern Ohio maple syrup producers in the period of 1946-1949. The purpose is to illustrate the importance of different sized containers and the average prices received. In doing this it was not possible to definitely relate quality to price in the different containers. However, it is likely that part of the higher price for the cans containing less than one gallon and for the bottles (when converted to price per gallon) is due to quality. Part of the difference is due to the increased cost per gallon of small containers.

Table 10.—Sales of Maple Syrup Classified by Size and Type of Containers, Group of Northeastern Ohio Producers, 1946 to 1949 Inclusive.

	Number of packages	Amount Sold (Gallons)	Amount Sold (Percent)	Average price per gallon
Gallon tin can	40,795	40,795	86.0	$4.76
½ Gallon tin can	4,145	2,072	4.4	5.62
¼ Gallon tin can	1,111	278	0.6	6.03
1 pound glass bottle	966	88	0.3	7.72
Bulk sales*	12	688	1.4	3.95
Bulk sales*, buddy syrup included	689	3,447	7.3	3.21
Total		47,368	100.0	$4.69

* Includes drum, 5 and 10 gallon cans, and a few in gallon cans furnished by the purchaser.

In addition to the above a total of 2,954 gallons were retained by producers for home use including gifts. This would be approximately 12 gallons for each producer per year. Also, some syrup was retained for further processing and sale as maple cream and sugar. In a few cases this brought in some additional income. The amount of syrup used for this purpose by the 60 producers covered by this study is estimated to not exceed a total of approximately 100 gallons per year.

As illustrated by the above figures the gallon tin can holding 11 pounds of syrup of U. S. standard density, is the most usual package in which pure maple syrup is stored and sold to the ultimate consumer. Within the limits of average current annual production, consumer acceptance of syrup in this size package is not questioned. In other words, the majority of Ohio maple syrup producers sell a high proportion of their syrup to consumers who are in the habit of buying a year's supply at one time. On the other hand, it may be recognized that this is contrary to consumer buying habits in general. The typical city dweller is in the habit of buying food in small packages for immediate consumption. Pure maple syrup in such a package is not generally found on grocers' shelves. Instead, various blended syrups flavored with 15 percent of maple are widely merchandised. Relatively little Ohio syrup has been sold for blending in recent years. The syrup sold in bulk (50 gal, drums, etc.) to wholesale dealers has been separated into two price categories which probably reflects a difference in average quality. An occasional producer still prefers to market in bulk at a little lower price to avoid the expense and labor of packaging in gallon cans.

How Much Does Quality Affect Price?

Under the marketing conditions prevailing in recent years a very small percentage of the syrup crop was sold at less than the standard price because of poor quality.

In 1946 the ceiling price on direct producer-consumer sales was $3.39 per gallon; which was undoubtedly lower than a free market price would have been because of a short crop and very active demand. As a result no sale (as reported by 62 producers in 1946) was lower than $3.39 per gallon. Under the free market of 1947 to 1949 inclusive, the prevailing price was $5.00 per gallon for good quality syrup. It is presumed that much of this but not all would have graded either U. S. AA Fancy or Grade A. In the absence of organized inspection the verification of quality was dependent on seller's description and buyer's inspection, or acceptance without inspection. Some very good syrup was sold at $4.00 and $4.50 in 1947 to 1949 inclusive, because particular producers wished to maintain a special pricing policy in respect to some of their old established customers. In these three years, 1947-49, less than 2 percent of the syrup sales were at a price of less than $4.00 per gallon or within the range of price which applies to distinctly buddy, cloudy, scorched or otherwise lower grade syrup. In the same three years about 10 percent of the syrup sold in the price range of $4.00 to $4.99 per gallon, 75 percent at $5.00 to $5.50 per gallon, and 13 percent in the price range of $6.00 to $8.00 per gallon. Syrup in this highest price class was mainly early run syrup for which some special demand exists.

The Importance of Price

The long-term decline in maple syrup production can in part be attributed to an unsatisfactory price situation. An important segment of the producers in the past have experienced years and periods of years when the market price received for syrup would not cover the cost of production. Even in the period of this study some produced at a loss, their cost being $5.00 to $8.00 per gallon. Only since 1946, the last year in which a ceiling price of $3.39 per gallon was imposed on direct sales to the consumer, has the price of syrup been high enough to encourage increased production.

The 4-year average cost of production of individual producers ranged from less than $2.00 to more than $5.00 per gallon of syrup as illustrated by the height of the line in Figure 17. A few producers who kept records for one to three years had even higher costs.

The market price (received by farmers) since 1946 has been high enough to allow most producers a margin of profit. Previously this margin was narrower. During the 1930's average market price (U. S.) per gallon of syrup ranged from a high of $2.03 in 1930 to a low of $1.18 in 1933, and averaged $1.55 per gallon for the entire decade. The average price (U. S.) was $3.30 in 1946, $5.18 in 1947, $4.78 in 1948, and $4.43 in 1949, or approximately the same as the Ohio prices recorded in this study.

Over a period of years production can be maintained through the operation of two circumstances: (1) the market price must be high

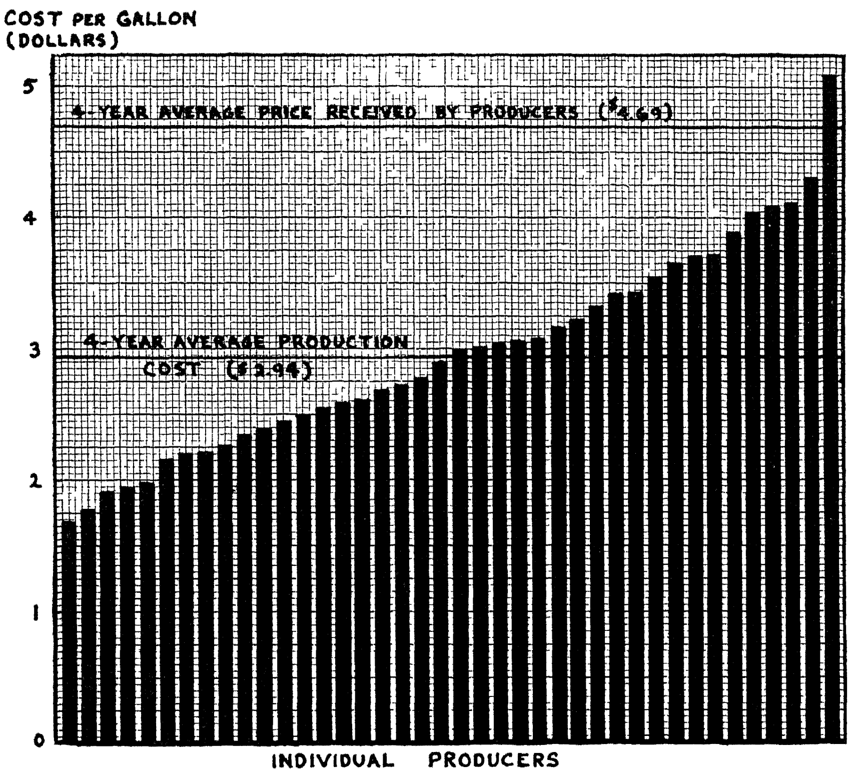


Figure 17.—Array of the 4-year (1946-1949) Average Production Cost Per Gallon of Maple Syrup, 40 Northeastern Ohio Producers, Compared with the Average Cost of Production and Market Price.

enough to cover the production costs of the higher cost producers; (2) by changes in methods of production and sugar bush management the producer may be able to lower production costs. The major part of this bulletin is devoted to the study of ways and means to lower production costs. At this point let us consider the first proposition, maintaining price.

Maintaining market price high enough to encourage production by the higher cost producers has its limitations because consumer reluctance to pay higher prices limits demand. At least under the present system of marketing it can be almost taken for granted that the demand and supply have been fairly well balanced by going prices. On the other hand, the prevailing method of marketing does not reach a very broad potential market. From the practical viewpoint it may be that maple syrup production is so limited in volume that a very elaborate system of merchandising is out of the question. None-the-less, merchandising techniques merit the continued attention of producers. Maple syrup is not a prosaic product. It has tradition and folklore to enhance its

Figure 18.—The municipally-owned sugar bush, Burton, Ohio.
Tapping time in the Municipal Park, Burton, Ohio. For years this has been operated as a sugar bush, indicating the community interest in maple syrup. Maple products are sold from the rustic log sugar house in the background.

flavor appeal. This is widely recognized but not fully capitalized in the marketing of pure maple syrup.

Advertising, standardization of grade, small packages, and general distribution through existing channels of the retail trade all involve expenses and can be fully established and maintained only through a large volume of business. All of these things have been done to a limited extent individually and by groups of producers. The annual Maple Festival held at Chardon, Ohio is an excellent example of community action to display the merits of maple products before the public.

THE IDEAL SUGAR BUSH

Perhaps no ideal bush exists. However, individual producers may profit by having some such ideal in mind and shape management in that direction. Several things have been tested in this study which can be summarized by a discussion of sugar bush management.

To summarize.—Economical maple syrup production is dependent primarily on: (1) having maple trees which flow sweet sap; and (2) enough trees to afford investment in the more efficient syrup making equipment. To these basic requirements may be added the many items which make up efficient operation, such as: (1) dry, seasoned fuel wood; (2) clean equipment in good repair; (3) recovery of all good sap runs; and (4) the necessary "know how" acquired through experience and observation. Many operating skills are taken as a matter of course by established producers and are important, but were not given special emphasis in this report. The trend is toward more investment in equipment to save labor; which suggests a further increase in the size of bush necessary to secure maximum efficiency as measured by cost. The above general conclusions are based on the more detailed summary and conclusions recorded in the front part of this bulletin.

In respect to site and soil the prime test is the ability to grow a vigorous, large-sized maple tree producing sweet sap. If that ability is present in the site, the slope and topographic features are relatively unimportant except as they may affect the ease of gathering sap. The farm sugar bush (or sugar orchard) may be located on land not well adapted to open land uses but still well adapted to growing maple trees.

The ideal sugar bush must meet a combination of three requirements: efficiency in the use of (1) labor, (2) equipment, and (3) land. As tested in this study, the first two requirements are best met by the size of bush hanging a minimum of 1,200 to 1,500 buckets. No upper limit on maximum size was indicated except costs per gallon showed no tendency to decline and even increased slightly in those bushes hanging more than 2,000 buckets.

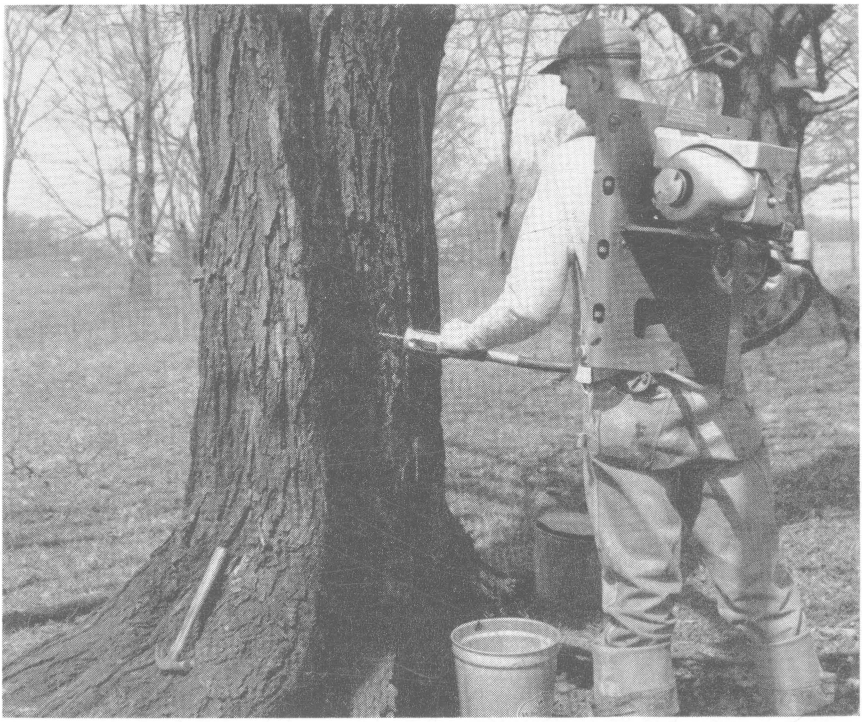


Figure 19.—More mechanization comes to the sugar bush. The tapping process is considerably speeded up by the use of such a tapping machine.

No particularly significant differences in cost per gallon of syrup was related to the records where more than 30 buckets per acre were hung. Time of gathering sap is obviously increased when the buckets are thinly scattered over a large area; but this handicap is obscured in the records by the fact that scattered trees of the open grown type produce sweet sap which takes less boiling time.

In the test for efficiency in the use of land the records indicate a definite opportunity for improvement in the majority of cases. Theoretically it is possible to hang at least 120 buckets per acre in a pure stand of maples spaced to utilize all the ground and sunshine. In contrast, this study indicated that producers actually hung an average of 37 buckets per acre; and the inventory of their woodlands indicated that at the recommended standards of tapping they could hang an average of 40 buckets per acre. Because the number of buckets hung per acre by individual producers ranged from less than 20 to more than 100, it is reasonable that as a practical proposition the average could be raised to 80 buckets per acre in most cases over a long period of time. This

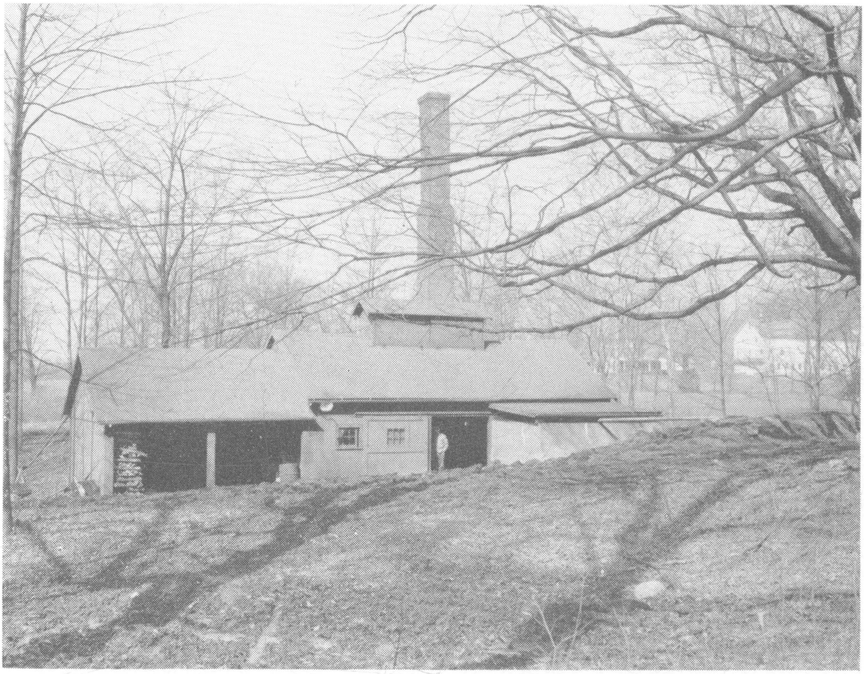


Figure 20.—A convenient, modern, well-constructed sugar house located in northeastern Ohio. Note the handy fuel shed located away from the evaporator steam, the electric flood lights, windows, permanent brick chimney, and the sheltered storage tank.

view is supported by the fact that in the average bush only one-half the stems 10 inches and over were maple trees.

The tests indicate that the open-grown, large-crowned type of maple tree produces more and sweeter sap than the long stemmed, small crowned, forest type best adapted to timber production. A maximum stand of the large-crowned type of tree can be obtained by either of two methods: (1) by the management of existing stands; or (2) by a new plantation. The former will be discussed first.

Gradual removal of species other than maple will provide space needed by existing maples and for replacements. This needs to be done very gradually to avoid wind damage to the maples which are shallow rooted when grown under forest conditions. The above plan of management of a natural stand would eventually lead to an all-age stand of pure maples which would perpetuate itself.

The second alternative is the maple orchard. This can be developed by repeated thinnings of a young natural stand on a favorable site.

Figure 21.—Sugar house operated by one of Ohio's largest maple syrup producers. Note gravity pipeline leading from tank on hill above, and large covered storage tanks on the north side of the sugar house.

Or, young maples may be planted. If the latter procedure is followed it is suggested that the young maples be obtained from an area where the trees run sweet sap. The site selected for the plantation preferably should be one where it is known that maple trees grow well and produce sweet sap. Thus, the advantages of heredity, soil and site will be utilized so far as possible. The handicap of a young plantation is the long waiting period, 25 to 35 years, before the trees reach a "tappable" size. Some financial return from the land might be realized by growing Christmas trees or post timber interplanted among the maples.

A maple plantation with 20-foot-square spacing would have approximately 110 trees per acre, one with 19-foot spacing 120 per acre and theoretically would hang that number of buckets. As the trees grew it would be necessary to remove some from time to time to prevent crowding. But, the stand would continue to support about the same number of buckets through successive thinnings until eventually 30 trees would be hanging 4 buckets each if there were no loss. Tree mortality

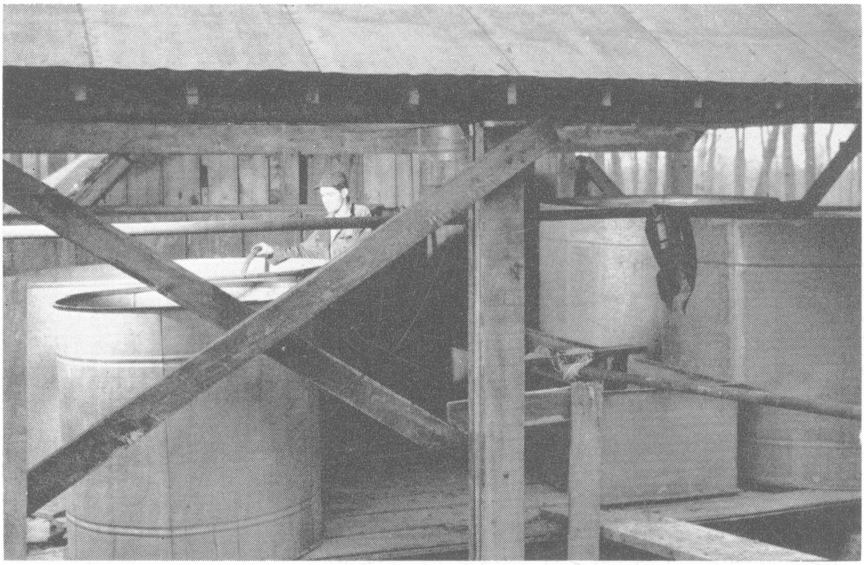


Figure 22.—Large capacity storage tanks which may be filled by a gravity pipeline or directly from a collecting tank. Note the shelter which helps protect the sap from sun and dirt. Sap is gravity fed into the evaporator in the adjoining sugar house.

might prevent the maintenance of this theoretical limit on the number of buckets which is higher than the upper limit observed in any of the sugar bushes studied.

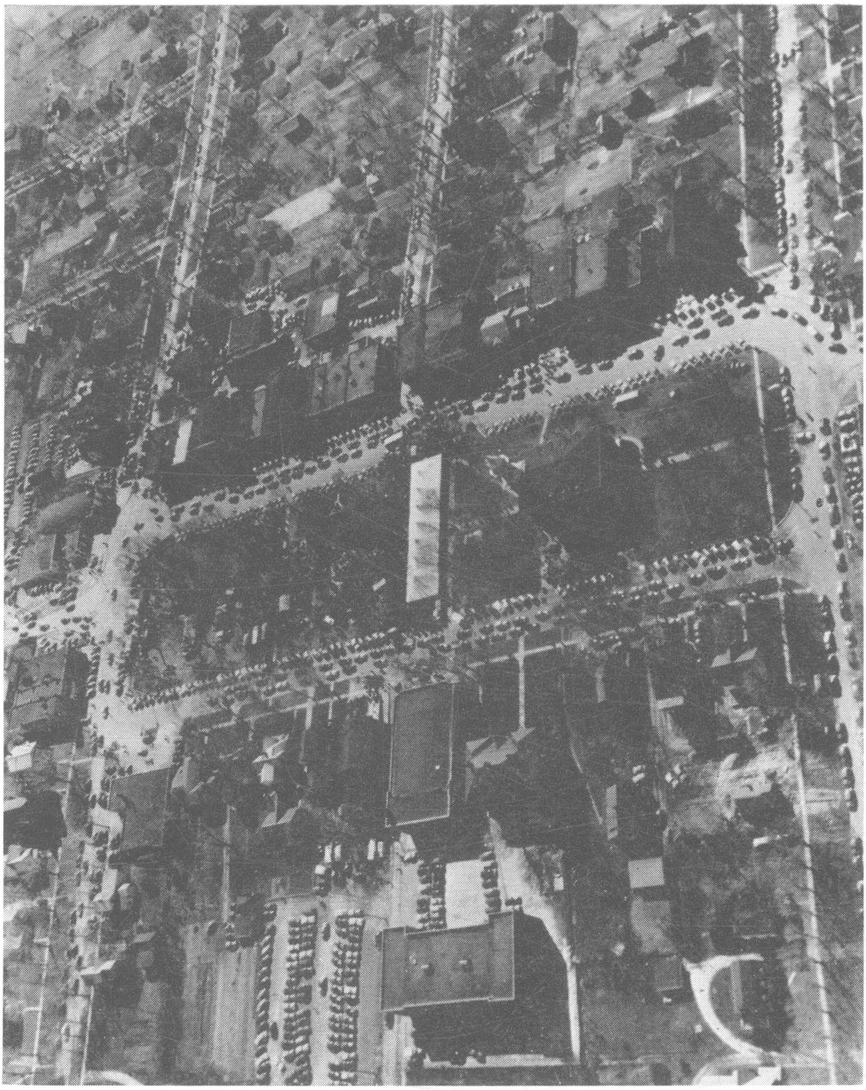


Figure 23.—Maple Festival Time at Chardon, Ohio. This annual event draws thousands of people to this center of Ohio's maple industry.